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MINES

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MINES AND MINING.

CHAPTER I.

GENERAL VIEW OF MINES.

Mines defined—Features of metalliferous districts—Mineral veins—Their extent, width, and direction—Occurrence of tin and copper—Cornish mines—Botallack mine, submarine—Wheal Cock—Wherry mine—Andean mines—Persburg iron mines—Concealment of a silver mine—Tragical event in Peru—Greatest depth of mines—Absolute and relative depth—Subterranean temperature—Greater cold of tin veins—Increase of temperature with depth—Experimental results—General conclusions.

With the subject of natural caverns, to which attention has been directed in a former volume of the Monthly Series,* we may appropriately connect a view of those artificial excavations, descending to a varying depth beneath the surface, which have been conducted by civilized and some semi-barbarous nations, in the quest of mineral wealth. By these performances of nature, and the operations of man, a limited portion of the earth's mass has been opened to the processes of observation and induction; and some definite conclusions have been obtained, by skilful interpretation of the disclosures afforded, respecting the character and constitu-

* "Caves of the Earth."

tion of the materials of the globe. The theme recommends itself to the reflective mind by the interest of the objects to which it refers; by their high utility to mankind in the progress of the arts, manufactures, and science; and by the striking illustrations furnished of the truth, that He who "laid the foundations of the earth," and launched it into space, has contrived and disposed its elements to meet the wants and promote the comfort of dependent creatures, so that through all the orbital revolutions of our terrestrial home, it signalizes to its inhabitants the infinite wisdom, goodness, and power of its Divine Architect.

When a mine is spoken of, the imagination is apt at once to picture a drear and deep vacuity, chilling by its damps and repelling by its darkness, never reached by the natural light, and maintaining only a very feeble connexion with the external air. But neither etymology, popular usage, nor the actual position of many mining sites, sanctions a restriction of the term to an underground locality. An adventurer of the present day, bound for California, to gather up its gold, never dreams of becoming a subterranean labourer, but simply of examining the surface; and is soon made aware of the fact, if not previously informed, that to deepen his researches would only involve a greater amount of toil, with less profit, till at a very scanty depth not a metallic particle would be found. The gold and diamond mines of Brazil are chiefly in the beds of shallow

rivulets, or in the superficial alluvial deposits of exhausted streams, though an amount of the precious metal is there obtained by deep workings in the solid rock. Tin, in Cornwall, is to some extent procured from stanniferous gravels, only slightly covered with other gravel, or with clay, sand, or peat; and that of the island of Banca, in the eastern archipelago, one of the most prolific tin regions of the globe, is entirely derived from a similar position. The rich mines of the Ural and Altai mountains are excavations in auriferous sand, or shingle, quite as open and shallow as an ordinary English gravel-pit. There are other metallic ores, which are sometimes obtained by open workings, and this is also the case occasionally with coal. Thus the apparently inexhaustible iron mines of the Isle of Elba, and a considerable number of those in Sweden, are simple quarries; while copper frequently occupies a completely superficial position, as at present in South Australia and on the shores of Lake Superior. A mine is the depository of a mineral, which may crop out, as it is technically termed, at the surface, or approach closely to it, or be profoundly buried beneath a vast aggregate of foreign matters.

Still, subterranean operations are required in order to obtain some of the more valuable mineral products; while, excluding gold, by far the largest proportion of the supply is derived from deep and extensive underground workings. To these sites attention will be exclusively confined in the present chapter.

The districts distinguished by great mineral riches are marked with a very distinct physiognomy. They are not extensive plain countries, but have, almost without exception, either a mountainous character, or are traversed by bold hills and elevated moors, while the immediate sites of mines are usually poor and barren in relation to agriculture, wild, heath-covered, and generally treeless, with few pretensions to the picturesque, and few scenes of rural beauty. Thus, in Europe, the repositories of the metals appear in connexion with the bleak Scandinavian highlands, the rugged tracts of Brittany and Spain, the elevated ranges of the Harz and Erzgebirge, the Pyrenean, Alpine, Carpathian, and Ural chains; while the great plains of Russia, Germany, and France, which are luxuriantly clothed with spontaneous vegetation, or return to cultivation the finest harvests of cereal produce, are either entirely destitute of metallic wealth, or possess but very sparing indications of it. The same contrast appears in our own country. On the one hand, not reckoning the collieries, and excluding iron, an almost universally disseminated metal, the broad valleys of the Forth, Clyde, and Tweed, the gently undulating levels of central, eastern, and southern England, and the central plain of Ireland, richly pastoral and agricultural localities, yield hardly any metallic treasures. On the contrary, the grand chain of the Grampians, the Lowther hills, and the bold heights of the Cumbrian mountains, the high moorlands of Northumberland, Durham.

west Yorkshire, and north Derbyshire, the ranges of North Wales, the granitic masses of Cornwall and Devon, and the elevated tracts of Wicklow and Wexford, yield copper, tin, lead, or zinc, with a portion of silver, and some traces of gold.

The important products extracted from the bowels of the earth by mining skill and industry are found disseminated in two general forms. They occur in cracks and fissures, with which most rocks are irregularly traversed, as is the case with the metals; and in regular beds or layers, alternating with other strata, of which coal and clay ironstone are the principal examples. The latter is the most common ore of the metal worked in England, but in various home localities, and abundantly on the continent, rich iron ore is met with under the first condition named. The metalliferous fissures are variously called *veins*, *lodes*, and *courses;* and the metal contained in them, being generally combined with other substances, bears the name of *ore*. This metallic matter, or ore, rarely occupies the whole of the vein, but is disseminated, more or less abundantly, through different kinds of earthy minerals, as quartz, clay, or carbonate of lime, termed the *matrix* or *veinstone*. When a vein continues straight, it is said to be regular; and irregular, or a *pipe vein*, when it occasionally swells or contracts. The expansions are termed *bunches;* and branches from the vein are styled *strings* or *threads*, according to their size. Sometimes the miner suddenly arrives at a piece of dead

ground, where the vein divides into branches, a string of ore extending on either side, in which case the vein or lode is said to *take horse.* Frequently productive veins are crossed at right angles by those which are unproductive, or non-metalliferous, known as *cross courses*, which not only interrupt the continuity of the lode, but heave it out of the line which it would otherwise have pursued, to the extent of from two feet to three hundred. Price mentions a tin vein in the Pink mine, Cornwall, intersected by three cross courses, and heaved each time out of its original direction ; at first a hundred and thirty feet, next about fifty-four, and then about two feet.

With regard to the *extent* of veins, they are known to run five, ten, or more miles through a country. In fact, though their termination is supposed to have been reached, in a few instances, at a considerable depth, yet in most cases, perhaps in all, their absolute extent is unknown, as the miner abandons them when further working will not repay his toil.

The *width* of veins is very various. It may average three or four feet, expand to eight or ten, and contract to an inch or two across. The value of a vein is far from being regulated by its diameter, for it may be broad and poor, narrow and rich. Some of the veins in Cornwall, when from thirty to forty feet wide, are less productive than when only three or four feet in width ; and in some cases they are worth working, owing to their extreme richness, when

not more than from two to four inches wide. In a tin mine at Limousin, a number of lodes repay toil, varying from half an inch to little more than one inch in thickness. One of the largest and thickest veins recorded is mentioned by Humboldt, in the celebrated Veta Madre mine, near Guanaxuato, in Mexico. It yielded, in the first ten years of the present century, four millions of pounds' weight (troy) of silver, varies in width from seventy-five to a hundred and fifty feet, is worked to the depth of upwards of a thousand feet, and has been followed horizontally through an extent of more than six miles.

It is a singular fact, that in the great majority of cases the productive veins run east and west; hence, those which follow this direction are commonly denominated *right running* veins. In the mines of North Wales, and in most of those of Cumberland, Yorkshire, and Derbyshire, the veins of lead, like those of copper in Cornwall, observe this course. It prevails also in Brittany, the Harz, Hungary, and Mexico. On the other hand, the unproductive veins, or the cross courses, usually containing only earthy materials, run generally in north and south lines across the metalliferous lodes. In passing through the rocks, the *underlie* of veins, or their inclination to the horizon, though varying, seldom exhibits any wide departure from a vertical position. The deviation rarely exceeds 10° in the north mining districts of England; but in Cornwall, where the copper and tin mines

disclose far more complicated phenomena than the northern lead districts, the deviation from the vertical is said to average 20°, yet seldom to exceed 45°.

Indications of metal in Cornwall are rarely met with at a less depth than eighty feet below the surface; the upper parts of the veins being filled with clay, gravel, and the debris of the neighbouring country. After becoming rich through a certain depth, symptoms of exhaustion are frequently observed on descending lower, the metallic ore diminishing in quantity, and deteriorating in quality, till the vein is given up on account of its poverty. The yield of argentiferous ore from the deeper parts of the great mine of Potosi, is said to be scarcely one-eightieth part so rich as from the workings nearer the surface, in the infancy of the mine. Pryce, writing of Cornwall in 1778, remarks, that "the richest strata for copper are between 240 and 480 feet deep, and for tin between 120 and 360; and though a great quantity may be raised of either at 480 or 600 feet, yet the quality is often decayed, or dry of metal." This may be true in many instances at present, but since the time of the writer, profitable copper workings have been extended to a far greater depth. Thus the Dolcoath copper mine, one of the oldest, most extensive, and important in the district, had in Pryce's time barely a depth of 600 feet, and was considered then scarcely worth pursuing; but it has since been worked at a profit to the depth of 1,800

feet. In November, 1814, a large cavern was discovered, upwards of 1,000 feet from the surface, which opened the way to rich metalliferous stores.

It is commonly believed that copper descends considerably below tin. Mr. W. Phillips observes: "At about 80 or 100 feet under the surface, the first traces of copper or tin are usually found, rarely nearer to it than 80 feet. If tin be first discovered, even without a trace of copper, it is not unusual that, in the course of sinking 80 or 100 feet, or more, all traces of it are lost, and copper only is found; but if, instead of tin, copper be first discovered, at a depth of 80 or 100 feet, it seldom or never happens that tin is found below it in the same vein." This statement may be correct generally, but there are many exceptions to it; for not only does tin occasionally accompany copper ore to a great depth, but in the Dolcoath mine, it underlies the copper at 1,200 feet below the surface.

Some of the mines of Cornwall are worked in very remarkable sites. The Botallack tin and copper mine, in the parish of St. Just, on the north-west coast of the county, near the Land's End, is especially celebrated for its romantic and exposed situation. The opening is made in cliffs of the boldest character, which rise abruptly from the boisterous waves of the Atlantic, and are descended by the labourers by means of ladders hung against the face of the rock. A steam-engine, situated on a rocky platform within a few fathoms of the sea, was

formerly one of the sights of the west. But this mine is most remarkable for a considerable part of its workings being actually submarine, extending nearly five hundred feet beyond low-water mark. It has thus been wrought beyond the memory of the oldest inhabitant, and so closely has the floor of the ocean been approached, that the heaving of its billows is distinctly heard by the workmen. At one time, tempted by the richness of the ore, they followed it so far upwards as to open a communication with the sea, but the openings being small, and the rock extremely hard, a covering of wood, with a cement of slimy turf, and the stony fragments of the beach, sufficed to exclude the water, and protect the labourers from the consequences of their rashness.

The mine of Huel or Wheal* Cock, in the same district, has been similarly extended under the sea, and is separated from it in some places by a roof so thin that the break, flux, ebb, and reflux of every wave is very audible, with the rumbling noise of every nodule and fragment of rock, continually rolling upon the submarine stratum. In violent, stormy weather, the noise overhead has been so tremendous that the workmen have often abandoned their labours, and retired to a secure spot, apprehending an inroad of the ocean. Small streamlets of salt water find their way through crannies, notwithstanding attempts carefully to exclude them, by

* The ancient Cornish called a mine *huel*, subsequently corrupted into *wheal*.

oakum and clay. "I was once," says Mr. Henwood, "underground in Wheal Cock during a storm. At the extremity of the level seaward, some eighty or one hundred fathoms from the shore, little could be heard of its effects, except at intervals when the reflux of some unusually large wave projected a pebble outward, bounding and rolling over the rocky bottom. But when standing beneath the base of the cliff, and in that part of the mine where but nine feet of rock stood between us and the ocean, the heavy roll of the large boulders, the ceaseless grinding of the pebbles, the fierce thundering of the billows, with the crackling and boiling as they rebounded, placed a tempest, in its most appaling form, too vividly before me ever to be forgotten. More than once, doubting the protection of our rocky shield, we retreated in affright, and it was only after repeated trials that we had confidence to pursue our investigations. Almost all the mines in the parish of St. Just, near the Land's End are similarly situated, and the positions of several of the steam-engines are highly picturesque; perched on the verge, and even on the ledge of a tremendous precipice, they seem at the mercy of every storm, and to the beholder from beneath they almost appear suspended in the air, and tottering to their fall."

But the now abandoned Wherry tin mine, in Mount's Bay, about half a mile from Penzance, is a still more extraordinary site, and furnishes a striking proof of man's disregard of

danger in the pursuit of gain. It was established on a shoal rock, seven hundred and twenty feet from the beach at high-water. The depth of water on it at spring-tides is nineteen feet, and the whole time of its being left bare does not exceed two months in the twelve. In winter, the sea bursts over the rock in a terrific manner, so as to render all attempts to carry on mining operations unavailing. Veins of tin were first discovered running in front of Penzance in the early part of the last century, and efforts were made to work them, but abandoned as hopeless. At length, in 1778, a poor miner had the boldness to assail the rock, and after immense difficulties, he succeeded in forming a water-tight case, as an upper part of a shaft, against which the sea broke, while a communication with the shore was established by means of a frail wooden bridge. As the work could only be prosecuted during the short period when the rock appeared above water, three summers were consumed in sinking the pump-shaft. Mining operations becoming practicable, the water-tight case was carried up above the highest spring-tides, and on a platform of boards lashed around the top, the necessary machinery for raising ores and other purposes was erected. But it was found impossible to prevent the water forcing its way into the shaft during the winter months, and equally so to remove the tin stone from the rock to the beach. The whole of that season was, therefore, a period of inaction, and it was not till April that labour could be resumed. A

steam-engine was finally established on the shore opposite, and connected with the mine by rods carried along the bridge. In this manner, ore to the amount of £70,000 was raised ; and the treasures were not exhausted when the adventure was brought to a close, in a way as romantic as its commencement. An American vessel, in rough weather, broke from its anchorage, and driving against the wooden outer works, demolished the machinery, and thus terminated an enterprise, which, both for ingenuity, hardihood, and success, has seldom been equalled in any country.

In opposition to these sites, the position of the Andean mines is frequently at an enormous elevation, their profoundest depths being still thousands of feet above the level of the sea. At sterile heights, where nature withholds all fostering influence from vegetable and animal life —where patches of scanty grass can scarcely draw nutriment from the ungenial soil, and quadrupeds shun the dreary and comfortless wilds—where man with difficulty breathes the rarefied air, and the condor alone finds itself in a congenial element—where storms rage with fearful violence, and the forked lightning plays around the mountain tops, while the peals of thunder are repeated by a thousand echoes—boundless stores of wealth are buried beneath the inhospitable surface, which have drawn a human population to localities wanting in every attribute to render their occupation agreeable. On the highlands of Peru, at the

height of 13,673 feet, which rivals the elevation of most of the crests of the Alps, stands the city of Pasco, famed throughout the world for its rich silver mines. Some thousand openings or mouths are the entrances into them, most of which are within the city, and lead direct from the dwellings of the mine-owners or the labourers. Happily, earthquakes are of rare occurrence in the district, for so complete is the undermining of the place, that it would require no violent shock to destroy its foundations, and bury it in the bosom of the earth.

In several of the Scandinavian mines, human labour is connected with strange contrasts, ice and heat, and exhibited under circumstances tremendously striking. In many cases, their entrances are frightful natural chasms, over which a platform partially projects, on which the machinery for raising the ores is placed. The verge of the platform enables the spectator to look down into the dreary gulf, the lower part of which is rendered impervious to the view by its darkness, but for some distance the eye can trace the scaling-ladders along the inward precipices by which the work-people ascend and descend. Dr. E. D. Clarke, who visited one of the iron mines at Persberg, in Sweden, states that, on descending "from the surface, large masses of ice appeared covering the sides of the precipices. Ice is raised in the buckets with the ore and rubble of the mine; it has also accumulated in such a quantity, in some of the lower chambers, that there are

places where it is fifteen fathoms thick, and no change of temperature above prevents its increase. After much fatigue, and no small share of apprehension, we at length reached the bottom of the mine. Here we had no sooner arrived than our conductors, taking each of us by an arm, hurried us along through regions of thick-ribbed ice and darkness, into a vaulted level, through which we were to pass into the principal chamber of the mine. The noise of countless hammers, all in constant action, increased as we crept along this level, until at length, subduing every other sound, we could no longer hear each other speak, notwithstanding our utmost efforts. At this moment we were ushered into a prodigious cavern, whence the sounds proceeded; and here, amidst falling waters, tumbling rocks, steam, ice, and gunpowder, about fifty miners were in the very height of their employment. The size of the cavern, over all parts of which their labours were going on, proved that the iron ore was deposited in beds, and not in veins, for then the work would have been more confined. Above, below, on every side, and in every nook of this fearful dungeon, glimmering tapers disclosed the grim and anxious countenances of the miners, for at the moment of our entrance they were driving bolts of iron into the rocks, to bore cavities for the gunpowder for blasting. We had scarcely retraced with all speed our steps along the level, and were beginning to ascend the ladders, when the full volume of the

thunder reached us, as if roaring with greater vehemence, because pent up amongst the crashing rocks, whence, being repeated over all the mine, it seemed to shake the earth itself with its terrible vibrations."

The effectual concealment of rich metallic stores, so that all knowledge of their site has been finally lost, is an incident which has marked the history of mining in South America, resulting from the grasping avarice of the Spanish governors. Tschudi relates, that a poor Spaniard, named Don Jose Salcedo, who dwelt in Puno, being attached to a young Indian girl, received the promise from her relations of having a rich silver mine disclosed to him on condition of his marrying her. The marriage took place; the mine was shown, and worked with the greatest success. But the report of his wealth soon roused the envy of the count De Lemos, then viceroy of Peru, who sought to possess himself of the mine. By his generosity and benevolence Salcedo had become a great favourite with the Indian population; and the viceroy took advantage of this circumstance to accuse him of high treason, on the ground that he was exciting the Indians against the Spanish government. Salcedo was arrested, tried, and condemned to death. Whilst he was in prison, he begged to be permitted to send to Madrid the documents relating to his trial, and to appeal to the mercy of the king. He proposed, if the viceroy would grant his request, that he would pay him the daily tribute of a

bar of silver, from the time when the ship left the port of Callao with the documents until the day of her return. When it is recollected that at that period the voyage from Callao to Spain occupied from twelve to sixteen months, some idea may be formed of the enormous wealth of Salcedo and his mine. The viceroy rejected this proposition, ordered Salcedo to be hanged, and set out for Puno to take possession of the mine. The tragical event occurred in May, 1669. But this cruel and unjust proceeding failed in the attainment of its object. As soon as Salcedo's death-doom was pronounced, his mother-in-law, accompanied by a number of relations and friends, repaired to the mine, flooded it with water, destroyed the works, and closed up the entrance so effectually that it was impossible to trace it. They then dispersed; but some of them, who were afterwards captured, could not be induced, either by promises or tortures, to reveal the position of the mouth of the mine, which to this day remains undiscovered. All that is known about it is, that it was situated in the neighbourhood of Cerro de Laycacota and Cananchari, in the southern district of Peru.

The greatest recorded depth within the earth which has been reached by human labour, 3,778 feet, only falls short of the height of Vesuvius by somewhat less than 200 feet. Comparing this depth with the elevation of the loftiest structures raised on the surface by the

hands of man, as the pyramid of Cheops, 474 feet, and the cathedral of Strasburg, about the same height, the former is in excess of the latter in the proportion of eight to one. In the following table, some principal examples of deep excavations and borings are introduced :—

	Feet.
Monkwearmouth coal mine, Durham	1,584
Valenciana mine, Mexico	1,686
Artesian well of Grenelle, near Paris	1,795
Shafts in the Newcastle coal fields, sometimes	1,800
Dolcoath copper mine, Cornwall	1,800
Tresavean copper mine, ditto, upwards of	1,800
Honenbirker mines, Saxony	1,827
Consolidated copper mines, Cornwall	1,920
Thurmhofer mines, Saxony	1,944
Ho-tsing, "fire springs" of China, sunk to obtain carburetted hydrogen gas	2,050
Joachimsthal mine, Bohemia	2,120
Apendale coal mine, Staffordshire	2,175
Samson mine, in the Harz	2,197
Boring at Minden, Prussia	2,231
Kongsberg silver mine, Norway	2,250
Kitzpuhl mine, in the Tyrol	2,764
Rörerbühel mines, Bohemia, now abandoned	3,107
Tseu-lieu-tsing, "place of continual flow," a fire spring, China	3,197
Kuttenberg mine, Bohemia, now abandoned	3,778

Comparing the *absolute depth* at these places, or that below the surface at the points named, with the *relative depth*, or that beneath the level of the sea, we find that many deep mines do not descend to the sea level. Thus, at the Joachimsthal mine, in Bohemia, the surface being 2,388 feet above the sea, and the depth 2,120 feet, it follows that the bottom of the mine is still above the level of the ocean. Humboldt found the absolute depth of the Valenciana mine, near Guanaxuato, in Mexico,

to be 1,686 feet; but the elevation of the mine's mouth being 5,960 feet, its deepest workings do not reach the level of the sea by 4,274 feet. The greatest depth below that level is recorded at Minden, amounting to 1,993 feet, the whole depth from the surface there being 2,231 feet.

Mines have afforded scientific inquirers interesting opportunities for examining the subject of subterranean temperature by thermometric experiments. At no great distance from the surface, but varying in different places, according in some degree to the nature of the subjacent substances, the effects of atmospheric temperature are found to cease. Well-known experiments in the caves of the observatory at Paris, show that all trace of annual or diurnal variation of temperature entirely disappears at the depth of twenty-five feet; and in various Prussian mining establishments, the same fact has been observed at depths ranging from. twenty-seven to sixty-three feet. Professor Forbes, from observations made in the neighbourhood of Edinburgh, states, that the effects of atmospheric temperature became insensible at the following depths in the substances named :—

In trap rock . . .	at	55	feet.
In loose sand . . .	„	65	„
In compact sandstone .	„	96	„

It has been known to practical miners, from time immemorial, that at equal depths granite rocks are always colder than the slates, which

has been attributed to the granite rocks being more exposed to the cooling influences of descending streams, their structure permitting the percolation of water more readily than that of the slate series. The impression is general, that rocks are colder than the metallic veins which traverse them; and though this is not a positively determined point, all observation confirms the truth of a popular opinion in mining districts, that veins containing tin-ores have, at equal depths, a lower temperature than those in which copper ores occur, while those in which the ores of both metals are mixed hold in this respect an intermediate position. No difference of opinion exists among Cornish and German miners as to the greater coldness of stanniferous deposits.

Everywhere, as far as observations have been extended, at a somewhat varying depth beneath the surface, a point is met with where the temperature is wholly unaffected by that of the external air, and remains invariable, differing very little from the annual mean of the country at the surface. Penetrating below this point, where external causes of heat cease to operate, the general fact has been clearly established, that a progressive elevation of temperature takes place, from some internal cause, and proportionably as the depth is extended. The ratio of the increase shows some divergence in different localities, as might be expected from differences in soils and rocks, and from the varying elevation of the sites. From

experiments carried on in the Prussian mines, Von Dechen obtained the conclusion, that in general the increase of temperature is much more rapid in coal than in metalliferous mines.

Mr. Henwood conducted a series of observations on subterranean temperature in the mines of Devon and Cornwall, confining himself as much as possible to that of the streams of water immediately issuing from those portions of the rocks and veins which had not been worked or broken by the miners. The reasons for this selection are obvious. In mines, the temperature of the air is affected by the presence of the labourers, the combustion of candles, the explosions of gunpowder, chemical decompositions, and other causes; and hence that of the water was preferred as it oozed from the unbroken rock, before the streams could be influenced by the temperature of the levels. Two results may be given from the published tables:—

	Depth.	Temp.
At St. Just	150 feet	51 degrees.
,,	420 ,,	56 ,,
,,	768 ,,	62 ,,
At Redruth	198 ,,	52 ,,
,,	456 ,,	58 ,,
,,	780 ,,	70 ,,
,,	1,062 ,,	86 ,,
,,	1,470 ,,	89 ,,

Similar results have been gathered in foreign mining localities from springs issuing from the rocks, of which the following are examples:—

Mines.	Depth in Feet.	Temp. of Springs.	Temp. at Surface.
Junghohe Birk, Saxony, lead and silver mine	256	48 deg.	46 deg.
Beschertghuck do.	712	54	46
Ditto . . do.	840	56	,,
Himmelfahrt . do.	735	57	,,
Kuprinz . do.	634	80	,,
Poullauen, Brittany do.	128	53	52
Ditto . . do.	246	53	,,
Ditto . . do.	459	58	,,
Huelgoet . do.	197	54	51
Ditto . . do.	262	59	,,
Ditto . . do.	394	59	,,
Ditto . . do.	755	67	,,
Guanaxuato, Mexico, silver mine . .	1,713	98	68

But observations to the same effect have been more largely obtained from the coal than from the metalliferous districts.

	Temp.
Whitehaven—Spring at surface . . .	49 degrees.
480 feet depth . .	60 ,,
Workington—Spring at surface . . .	48 ,,
504 feet depth . .	60 ,,
Percy Main Colliery, Northumberland—Surface	48 ,,
900 feet depth . .	70 ,,
Jarrow Colliery—Surface	48 ,,
Water at 882 feet . . .	68 ,,
Killingworth Colliery—Surface . . .	48 ,,
Water at 1,200 feet .	74 ,,

No exception has been noticed to this increase of subterranean temperature, where experiments have been conducted with proper care, and in sufficiently deep excavations.

The conclusion indicated by these experimental examinations, that some deep-seated source of heat exists in the interior of the globe, is in harmony with the intimations given by other phenomena of nature, which need no instru-

ments of science to detect, but lie open to popular observation. Thermal springs, with a temperature varying from that of summer warmth to that of boiling water, bubble up from unknown depths in the recesses of the earth, under the most diversified circumstances, in almost every region of the world. They are found far removed from the evidences of present volcanic action—oozing within the hot zone of the tropics, and under the cold of polar latitudes—amid the towering heights of the Himalaya, where perpetual snow mantles the surface, and in sheltered valleys, clothed with the richest vegetation—on the desolate and ever frozen soil of Greenland, where the poor Esquimaux bathes his pain-struck limbs in the genial current, and in some of the busiest scenes of European life, to which the invalids of a refined civilization are drawn. Powerful volcanoes exhibit the same wide geographical distribution, their smoking craters acting as the chimneys of an internal fiery furnace, which occasionally displays its flames from their summits, illuminating the regions of celestial space, and casting a lurid glare over miles of the subjacent country.

Whatever opinion may be warranted by the facts adverted to, respecting the existing condition of the globe at great depths, the positive conclusion may be drawn from them, that the means are prepared, are at hand, and in action, which only wait the fiat of the Almighty to reveal their energy, and realize the majestic

scene to which the page of inspiration refers, when "the elements shall melt with fervent heat, the earth also and the works that are therein shall be burned up." The Bible, in relation to that scheme of material things with which we are now connected, is a revelation of the past and of the future. It unfolds its origin, and proclaims its destiny. It takes us back to a period when Jehovah, supreme in his omnipotence, created the heavens and the earth; and it carries us forward to an era when the same power will be exerted to dissolve the existing system of nature, in order to raise out of its elements a nobler and more enduring sphere of life, to be occupied by holy and happy beings.

Scoffers, in ancient times, inquired, "Where is the promise of His coming?" and strove to fortify themselves in the disbelief of the announced consummation, by advancing the proposition, that "all things continue as they were from the beginning of the creation." But they were shallow reasoners. What, though the appearances of nature are substantially the same at present as in "the days of old, the years of many generations?" What, though we, in common with a remote ancestry, mark the recurrence of the same phenomena—the dawning day and gathering night—the fruits of summer and the storms of winter—the successive swell of the ocean, and the renewed verdure of the fields—while no symptoms of an approaching suspension of these events are apparent?

The fact argues but the faithfulness of God to his word, that "while the earth remaineth, seed-time and harvest, and cold and heat, and summer and winter, and day and night shall not cease;" and can only be legitimately used to confirm faith in the accomplishment of the record, that "the heavens and the earth, which are now, by the same word are kept in store, reserved unto fire against the day of judgment and perdition of ungodly men."

But it is an unwarrantable and false assumption, that an unvarying sequence of events has marked the history of terrestrial nature. Evidences of a great catastrophe in the past, when "the world that then was, being overflowed with water, perished," appear in the traces of submergence presented by all the existing dry lands; and with these memorials around us—with the indicated means of future change in present action, and operating with intense energy, though under merciful restraint—we do well to take heed to the sacred revelation of things to come as true and faithful, entertaining with becoming seriousness of mind the proposition, "Seeing then that all these things shall be dissolved, what manner of persons ought ye to be in all holy conversation and godliness, looking for and hasting unto the coming of the day of God." To be prepared for its arrival—to be accepted in the judgment of that day, and consequently calm spectators of its solemn scenes—are points of transcendent importance, only duly regarded when elevated

above all other considerations. Let them be made the great end and aim of life; and by a timely recognition of the Saviour, sure to be our Judge—by faith in his merits evidencing its genuineness in submission to his word—by a sanctified character formed by the power of the Divine Spirit—we shall become prepared to enter upon the inheritance of "new heavens and a new earth wherein dwelleth righteousness."

CHAPTER II.

GREAT MINING DISTRICTS AND PROCESSES.

The United Kingdom—Historical notices of tin, copper, and lead mining—Spain—Its ancient productiveness—French mining districts—*Ecoles des mines*—*Corps des mines*—*Annales des mines*—Germany—Academy and school at Freiberg—Neighbourhood of the town—Austria—Academy at Schemnitz—Norway and Sweden—The Ural mountains—The Altai chain—Ancient workings—Brazil—The Andes—Mexico—Ancient Mexicans and Peruvians—Rich silver mine—Accidental discovery of mines—Use of the divining-rod—Indications of veins—Mining arrangements—Principal works—Examples of enterprise.

THE important mines of the UNITED KINGDOM comprehend those of coal and ironstone, and of the ores of tin, copper, zinc, and lead, the latter containing some proportion of silver. Of these, the coal mines, or collieries, are by far the most extensive. They are variously dispersed in the northern, midland, and western counties of South Britain; in a broad belt of country, which traverses the centre of Scotland, from the shores of Ayrshire to those of the Firth of Forth; and in several parts of Ireland, the produce there being poor in quality and inferior in quantity. But the localities of these invaluable tracts will be hereafter specifically denoted. The principal iron mines are in the

South Welsh, South Staffordshire, and Scottish coal fields, where the ironstone occurs in beds, alternating with layers of coal and other strata, and is usually raised from the same pit as that from which the coal is extracted. The remaining metals, instead of forming beds more or less horizontal, are found in veins, traversing the more solid rocks in the mountainous region of the kingdom.

Tin is obtained only from the granitic and slaty rocks, which extend from Dartmoor, in Devonshire, to the Land's End, in Cornwall. This district is the most productive source of copper ores, which are also furnished by North Wales, the Isle of Anglesey, Cumberland, and a few other places. It contains likewise mines of lead and magnesia, and supplies many other metals, zinc, arsenic, cobalt, and bismuth. The next remarkable metalliferous district is in the north of England, on the borders of Northumberland, Cumberland, Westmoreland, and Durham, where the mountain limestone, intermingled with gritstone and shale, forms an elevated dreary tract, of which Alston Moor may be deemed the capital. The ores here are lead, veins of which are wrought in the hilly country of North Derbyshire, though now comparatively poor. In Wales, Flintshire contains an important group of lead works, and scattered mines occur in the neighbourhood of Plinlimmon and Snowdon. In Scotland, extensive mining operations for lead are carried on in the clay slate mountains on the borders of Lanark-

shire and Dumfriesshire. In Ireland, the slate and limestone ranges contiguous to the sea-coast, which inclose the great central plain, contain mines of copper and lead, but chiefly of the former.

Mining for *tin* in Cornwall dates from a remote and unknown antiquity. The singular excavations, called the "Pit," in Gwennap—the "Land's End Hole," at Tol-peden-Penwith—and the "Devil's Frying-pan," near the Lizard Point, are undoubted works of the ancient Britons. The metal found its way to the markets of southern Europe in very early times, either by the direct maritime commerce of the Phœnicians, or, more probably, as during the Roman period, by the passage of the Channel, and land transport through Gaul. Its value is commonly thought to have induced Athelstane, the first Saxon who appeared as a victor at the Land's End, to effect the conquest of the district. A small quantity of gold being associated with the tin alluvium, as is the case at present, seems to have originated the fallacious idea, that the country at large possessed considerable supplies of the precious metal, which only required a careful search to be discovered. Under the Plantagenets, the tin trade was chiefly monopolized by Jews, who originated and named the market-town of Marazion, signifying the "merchants of Zion," on the shore of Mount's Bay, which is still called by the country people, Market-Jew. Curious remains of old smelting works, of the most primitive

character, are still observed in valleys and sheltered spots, which are traditionally called Jews' Houses. "In the time of king John," says Dr. Borlase, "I find the product of tin in this county very inconsiderable, the right of working for it being as yet wholly in the king, the property of the tinners precarious and unsettled, and what tin was raised was engrossed and managed by the Jews, to the great regret of the barons and their vassals." In the reign of Edward I., the tinners of Cornwall were made a distinct body from those in Devonshire, the tinners of both counties having been accustomed previously to assemble together on Hengston Hill, every seventh or eighth year, to concert the common interest of both parties. Formerly, all tin paid a duty to the duke of Cornwall, or to the crown during a vacancy in the dukedom, but the tax was abolished in the year 1838 for the benefit of the miners, whose operations had become unprofitable.

The origin of English *copper mining* is involved in complete obscurity, but the Romans are traditionally reported to have explored the Paris mountain, in Anglesea, one part of it still bearing the name of the Roman work. Cumberland was the chief, or the only productive district, down to the year 1270, when a rich copper mine was worked near Keswick, of which the duke of Northumberland was subsequently dispossessed by queen Elizabeth, "because of its holding so much silver and gold in the ore," the precious metals belonging to the sovereign.

The total amount of copper produced in the kingdom must have been very inconsiderable, for, in the reign of Henry VIII. and his successor, acts of parliament were passed to prohibit the exportation of copper, brass, and other alloys, "lest there should not be metal enough left in the kingdom for making of guns and other engines of war, and for household utensils." At a later period, about 1670, the Staffordshire mines are alone mentioned as remarkable for copper. Still, in 1694, when a copper coinage was first issued, Swedish metal was made use of, money being first coined from English copper in 1717. It was only a few years before this period, that attention was directed to the vast stores of the valuable ore in Cornwall. Intent upon seeking for tin, the old miners had been accustomed to throw aside the copper ores as worthless, or to abandon all further search upon encountering them, under the idea that the copper spoiled the tin. In this manner, the hill of the Tresavean copper mine, which has been a source of immense wealth to its proprietors, and of subsistence to thousands, was formerly worked over for tin, and deserted because of its abundant supply of the other metal. In 1768, vast stores were discovered in the northern part of Anglesea, and about the same period, at Ecton Hill, in Staffordshire, both places yielding a large annual produce for several years, though now exhausted.

The early history of English *lead mining* is better known than that of copper, and is certainly

of far higher antiquity. The notices of it refer to the Peak of Derbyshire. At the time of the Norman survey, seven mines are mentioned in the Domesday Book. But, in the year 835, Kenewara, abbess of Repton, granted her estate at Wircesworth, now Wirksworth, to Humbert the alderman, on condition that he annually gave lead, of the value of three hundred shillings, to archbishop Ceolnoth, for the use of Christ Church, Canterbury. That the mines were known to the Saxons, previous to the introduction of Christianity, may, perhaps, be inferred from the circumstance of a mine, near Castleton, bearing the name of Odin, that of one of their deities. They were undoubtedly worked, if not commenced by the Romans, as several blocks of lead have been discovered in the district with Roman inscriptions. One found on Cromford Moor, in 1777, had the following sentence, *Imp. Caes. Hadriani. Avg. Mai. Lvi.*, which has been interpreted, "The emperor Cæsar Hadrianus Augustus, from the mines of Lutudarum." Another, discovered at Matlock, in 1783, had an inscription presenting considerable difficulty, as the words were much abbreviated, and consisted of compound letters, but it was supposed to signify, "*Lucius Aruconius Verecundus*, from the mines of Lutudarum." The place named was a Roman station in the county, probably at or near Chesterfield. The brazen dish, by which the measures of ore were regulated in the Low Peak, to be paid as dues to the lords of manors and others, has the date inscribed

upon it, "the fourth day of October, the fourth yere of the reigne of Kyng Henry the VIII.:" "This Dyshe to Remayne in the Moote hall at Wyrksworth, hanging by a cheyne, so as the Mchanntes or Mynours may have resorte to the same att all tymes to make the trw mesure at the same."

No country equals Great Britain in having such an amount of varied mineral wealth stored within the same area. It has been wrought with indefatigable energy by hardy labourers, in general under the guidance of intelligent superintendents, whose industry and enterprise have largely augmented the resources of the nation. At the same time, for want of a proper school of mines among the institutions of the country, in which mineralogy and mining should be practically taught, and the facts which experience accumulates registered, a vast amount of capital has been wasted in speculations, which instruction would have shown to be absurd or unprofitable. The establishment by government of a Mining Record Office, in connexion with the Museum of Economic Geology, is an improvement of recent date.

Some of the principal seats of mining adventure abroad may now be noticed, but the subject is so extensive that a glance must suffice.

In SPAIN, lead occurs in great quantity in the mountain chains, and is a prominent article of export; quicksilver is obtained from enormous veins of cinnabar in the province of La Mancha,

where the mines have been open since the time of the Romans; tin is found in Gallicia, where it was a known product in very early times; ores of iron are abundant; and the silver mines, abandoned in the dark ages, are now reworked with success. But the political distractions of the country, and the moral degeneracy of the people, have prevented the development of its buried treasures. Its ancient richness in the precious metals is historically recorded; but lying exposed at the surface, or to be reached by slight excavations, the gold was speedily exhausted, as will be the case, at no distant date, with the brilliant product in California. So abundant was the silver, that some of the commonest implements of the inhabitants were composed of it. When the Phœnicians first visited the shores, they are said to have found the metal in such quantities, that they freighted their ships with it to the water's edge, and used it for their ordinary utensils, anchors not excepted. Thus laden, they returned back to their native country, which lost no time in taking possession of this Mexico of the ancient world, and establishing colonies there. It is highly probable that the Tarshish of prophecy is the Tartessus of Phœnician commerce, a name which may have indicated one of their particular settlements in Spain, but was certainly applied to the whole south of the country under their dominion. With the ships of Tarshish, Tartessus, or Spain, the prophet Isaiah associates gold and silver; while the prophet

Ezekiel, in a reference to the commerce of Tyre, enumerates silver, iron, tin, and lead, as imports from the same quarter.

In FRANCE, the chief mining operations are conducted in Brittany, the Vosges, and the country around St. Etienne, near Lyons, the principal metalliferous ores being those of iron and argentiferous lead, with some tin, copper, antimony, and manganese. The last-named locality is the most important coal field. France is vastly inferior to England in mineral products, yet considerably in advance as it respects organization to develop them. Paris has its *Ecole des Mines*, founded in 1783, a school in which instruction is given in practical mining, metallurgy, and other branches of allied knowledge; a second was established in 1816, at St. Etienne, in the department of the Loire; and a third, in 1845, at Alais, in the department of Gard, each of which has its mineralogical collection. From the proficients in the schools, the officers of the *Corps des Mines* are selected—a body of mining engineers, appointed for various purposes, but chiefly to examine France in relation to its geological structure and mineral wealth—to guide the labours of those engaged in mines, or in the search for useful mineral substances—to indicate, from the knowledge which they have acquired of the mode of occurrence of mineral veins in a district, the kind and direction of the works to be carried on—to watch over, by frequent visits to mines and subterranean quarries, the preservation of the surface and buildings, the solidity

of the works, and the safety of the workmen—to assure themselves, by exact experiments, of the strength of the apparatus in which steam is generated—and to report to the higher authorities any infractions of the laws regarding mines, metallurgical, and other similar establishments. The engineers also occasionally travel, to obtain information respecting the discoveries made by, and the facts observed in, other countries; and publish annual records, under the title of *Annales des Mines*, devoted to the illustration of their department.

GERMANY, the cradle of scientific mining, and still its principal school, has two richly metalliferous sites—the Harz mountains, on the borders of Hanover and Prussia; and the Erzgebirge, or Ore mountains, which separate Saxony and Bohemia—yielding silver, copper, lead, and iron, with some tin and cobalt, the latter chiefly from the Saxon mines, which England imports from thence, while it lies in heaps in various home localities as a valueless product. Saxony has long been celebrated for the skill with which its mining operations are conducted, owing to the academy and school at Freiberg, devoted to the education of operatives, managers, viewers, and other officials. The institution, founded by prince Xavier in 1765, was placed under the care of Werner in 1775, and has had many of the most eminent men on the continent, as Humboldt and Leopold Von Buch, connected with it.

Mr. Hunt, the keeper of our mining records,

thus states his impressions respecting the Saxon mining capital, derived from a personal visit in 1840: "The advantages which Freiberg possesses for practical instruction are perhaps not surpassed by any mining town in the world; seated as it is upon the metalliferous gneiss, pierced by dykes of porphyry, it is within a walk of an extraordinary variety of geological formations. On the north-west we pass over the mica slate, famous for the remarkable mines of Braunsdorf, succeeded by clay slates and conglomerates of the so-called transition class, and by the singular coal field of Haynichen. Further west, we may visit the coal and rich iron ores of Zerickau. On the south, we reach the wild crest of the Ore mountains, where are situated the curious tin mines of Attenberg and Zinnwald; whilst, on the east, we may roam through the lovely valley of Thorandt, and investigate the relations of the coal measures, the new red sandstone, the green sand, and chalk marl, with the intrusive masses of porphyry and syenite.

"The metalliferous veins, exhibiting very distinct characters, may be classed in several groups, and present every species of relation one to the other; whilst in a circle round the town, with a radius of about three miles they give occasion to the working of nearly 100 mines, where about 200 shafts, 71,000 fathoms of adit or water course, and about 250,000 fathoms of level or gallery, exhibit every species of timbering and masonry, as

used in mining. In the neighbouring valley of the Mulda, the ores are daily roasted and smelted in twenty or thirty furnaces of various construction, and the beautiful process of amalgamation is always to be seen in action." An admirable regulation is strictly enforced in the Harz and in Saxony, that when a mine is abandoned a proper officer inspects it, to see that the workings are not left in a dangerous state, and to make a registry of its condition and site. Want of attention to this precaution in our own country has caused many fatal accidents, when exhausted or relinquished mines have been revisited; and especially in the coal districts is disaster courted, from old excavations being left open and unprotected, or becoming slightly covered over with rubbish, presenting the appearance of firm ground to the passenger.

Austria possesses vast masses of iron in the Styrian Alps, obtains an abundant supply of quicksilver from the province of Carniola; and has, in Hungary and Transylvania, the most prolific sites of the precious metals in Europe, with ores of copper, lead, antimony, and iron. The more extensive works are at Cremnitz and Schemnitz, where they have been in operation ever since the twelfth century. These towns are not far apart from each other, in a very roughly diversified country, formed by the roots of the Carpathian mountains. Schemnitz is the school of the Austrian miner. Its academy was founded during the reign of the

empress Maria Theresa, about the year 1760, for the purpose of educating officers to superintend all the mining and smelting works throughout the empire; but it has never acquired the celebrity of Freiberg. Here there are veins of gigantic dimensions, from twenty to two hundred feet wide; but they are worked with great difficulty and expense, owing to the rock decomposing rapidly, which renders it necessary to case the galleries with wood. Water carefully collected into reservoirs is employed to move the machinery required; while fuel for numerous smelting works is supplied by the thick forests of oak, pine, and beech, which clothe the hills. The drainage of all the mines in the neighbourhood is collected at a common level, six hundred feet below the surface, from whence it is conveyed by a gallery, twelve miles long, excavated under a lofty mountain ridge, a work remarkable for boldness of project and skill in execution.

Norway and Sweden are remarkable for enormous stores of iron and copper, with some silver; but the rugged character of the country, and the few navigable streams, render transport difficult, and check the extraction of its metallic possessions. Still, Sweden furnishes the best iron in the world, from the mines of Dannemora, immense open excavations. Swedish iron has been largely used in England for the manufacture of steel; and the silver mines at Kongsberg, in Norway, discovered in 1623, after a period of suspension, are now yielding a

large annual profit to the government. It was at this spot that the gold was found in 1647, of which Christian IV. caused the famous Billen ducats to be coined, bearing the legend, *Vide mira Domini*, "Behold the wonderful works of the Lord."

We now come to the RUSSO-ASIATIC mining districts, the Ural mountains, which form the boundary between Europe and Asia; and the Altai chain, on the southern frontier of Siberia. West of the Ural, or on the European side, a deposit of copper sand ore has been brought to light by the miner, extending with a perfectly uniform quality, 480 miles in length by 280 in breadth, or throughout an area of 100,000 square miles. But the great sites of wealth are on the eastern, or Asiatic slope of the chain, consisting of copper ores; iron, bulging out at the surface, the first product in point of mass, as well as financial importance, in the district: gold and platinum, obtained from the sands and gravel on the borders of the streams. Ekaterinburg, the mining capital, on the margin of the lake of Iset, is inhabited chiefly by merchants who own and work the mines, labourers employed in them, and lapidaries engaged in cutting and polishing the precious stones with which the region abounds. These are all Russians or foreigners, none of the native Bashkirs and Voguls understanding the value of the mineral products of their country. Their only concern, on the arrival of the first adventurers, was to have the remains of huge animals

imbedded in the soil respected. "Take from us," said they, "our gold, if you will; but leave us the bones of our great ancestors." The prosperity of the Ural dates from the reign of Peter the Great. It originated with Nikiti Demidoff, the ancestor of the present noble Russian family of that name, whose portrait is a favourite subject of artistic labour, usually represented grasping a sturdy staff, as the untiring explorer of the mountains. The woods of the Demidoffs, near Nevyansk, so essential to the working of the furnaces, cover an immense extent, and are still untouched over a wide area, where the elk has not been disturbed.

The riches of the Altai, principally silver, with gold from the sands, lead and copper ores, were not fully opened till a very recent date, though the first mine was commenced by the son of the Demidoff already named, in 1728. A few years afterwards, the works were begun which have grown into the present town of Barnaul, the focal point of the Altaic mines, the seat of their administration, and the chief smelting place. An official return of the Russian government, of the amount of gold collected in the Ural and Altai, from 1829 to 1848 inclusive, or through twenty years, gives a total of 16,420 poods; and reckoning each pood at £2,000, the result is £32,840,000 for the whole period, or an average of £1,642,000 per annum. It is remarkable, that in both these districts decided evidences exist, in pits and galleries, sometimes containing relics of

implements, of their treasures having been freely drawn upon in remote antiquity. Near the silver mines of the Schlangenberg, or Snake mountain, there is an ancient excavation, extending a thousand feet; and a stone sphinx, discovered in one of these ancient mines, of rude workmanship, is preserved in the museum of Barnaul. These monuments appear to throw light upon a statement of Herodotus, who, speaking of the Arimaspes, the most easterly Scythians of whom he could obtain any account, refers to their mines of gold, guarded by monsters and griffins, which Humboldt identifies in the bones of elephants and other animals, at present to be found in the steppes between the Ural and the Altai.

Turning to the NEW WORLD, the southern portion of the continent presents vast repositories of the metals in the mountain tracts of Brazil, and along the colossal range of the Andes. The former territory offers one of the few examples of successful subterranean operations for gold, in the rugged province of Minas Geraes, though the principal supply is obtained by digging and washing the surface soil, in which platinum and many gems are found accompanying the gold. In Peru, Bolivia, and Chili, auriferous deposits occur in the water-worn gravel, accumulated by streams in the deep valleys of the mountains. The two former countries are principally celebrated for immense veins of silver ore in the high Andes, at Pasco and Potosi, with quicksilver, copper, lead, tin, and other

metals, frequently too far from the coast to render working profitable, owing to the cost of transport. The latter, with similar products, has its most important series of mines devoted to the extract of copper, a considerable amount of the ore being sent to Swansea, in Wales, to undergo the process of smelting.

In North America, the lofty plateau of Mexico has been celebrated for its rich silver stores from the period of its discovery, from which a larger supply of the metal has been obtained than from any other part of the world. The total number of mines, of all kinds of produce, worked and disused, has been stated at three thousand. But here, as in most of the other parts of the continent formerly subject to the crowns of Spain and Portugal, the produce of the mines has declined since the era of independence, owing to the civil turmoils in which the republics then founded have been involved. Mexico, the city, has its *Mineria*, or school of mines, and few spots have received such a large amount of treasure as its mint, which occupies part of the palace of the former viceroys. Mr. Bullock, an English adventurer in the country, having obtained one of the silver mines of Themascaltepec, describes the formality of taking possession of it, similar to the ceremony of infeoftment under the feudal system in Europe: "The second day after my arrival, I was formally installed in the seigniory of the mine and adjacent lands, in the presence of some of the principal inhabitants and the padre of the town,

who attended for the purpose of witnessing the ceremony, which consisted of the proper officer taking me by the hand, at the mouth of the mine, and declaring me, in the name of the government, its right and lawful owner. Then, congratulating me on the possession of such a valuable property, he requested me to take three stones, and cast them in different directions, and afterwards to pluck up some weeds, and throw them away, to show that the land, and whatever it produced, were at my disposal."

The aborigines of the western world were well acquainted with its mineral treasures prior to the era of the European conquest. The Mexicans drew silver, lead, and tin, from the mines of Tasco; copper from the mountains of Zacotollan; and gold was gleaned from the beds of rivers, or from superficial debris. The former metals were not derived from masses lying at the surface, but from veins wrought in the solid rock, into which they opened extensive galleries. The monuments of their labour often served as a guide to the Spaniards in their researches. The Peruvians likewise gathered gold from the deposits of streams, and extracted silver from the bowels of their mountains. Yet they did not penetrate them by sinking shafts, but by simply excavating small openings in the sides. On the giant mass of the Illimani mountain, which overlooks the north extremity of the Bolivian plateau, Mr. Pentland found the face of a cliff literally honey-combed by innumerable mining openings.

However much report may have exaggerated the accumulations of gold and silver in the palaces and temples of the Incas, it is certain, from the experience of the early Spaniards, that they might have been enormous; nor is it strange to read of twelve immense vases of silver, with corresponding utensils, in the interior of the great temple at Cuzco, a building constructed of stone and thatched with straw. An example of the extraordinary produce of a Peruvian silver mine is mentioned by Tschudi. He relates, that the owner of the mines at San Jose, in the department of Huancavelica, requested Castro, the viceroy of Peru, who was his friend, to become godfather to his first child. The viceroy consented, but at the time appointed for the ceremony affairs of state prevented him from quitting the capital, and he sent the vice-queen to officiate as his proxy. To honour his illustrious guest, the mine-owner laid down a triple row of silver bars along the whole way (and it was no very short distance) from his house to the church. Over this silver pavement the vice-queen walked, accompanied by the infant and attendants. On returning, the munificent host presented to her the whole of the silver road, as an acknowledgment of the honour she had conferred on him. Since that time, the mines and the province in which they are situated have borne the name of Castrovireyna.

Mining labour, a punishment in ancient times in the old world, to which many of the

early Christians were devoted in ages of persecution, is still a penalty to which political offenders and criminal delinquents are condemned in Austria and Russia. Its records, in the opposite hemisphere, are sadly rife with acts of oppression and cruelty. That gold, to which Columbus referred king Ferdinand as the means which might even "extract souls from purgatory to people paradise," using this as an argument to induce him to win it, was the means of eliciting the worst passions of human nature, of carrying anguish to many a comparatively happy site, depriving thousands of their liberty, and finally extinguishing entire populations, after a series of years spent in compulsory and onerous toil. The natives of many of the West Indian islands were transported to Mexico to work the mines and perish; the Peruvians were largely devoted to a similar fate; and the first draughts of African Negroes borne across the Atlantic, were substitutes for the native races, as more competent to bear the drudgery which the rapacity of the European conquerors exacted. But retributive dispensations are not wanting in this dark and dismal story, which signalize the hand of an omnipotent and righteous Providence, and commend to our attention the truth, that there "is a God that judgeth in the earth." Violent deaths, often from their comrades, envious of their possessions and influence, befel many of the actual perpetrators of these crimes; while the mother-countries which sanctioned them, Spain

and Portugal, though annually having galleons freighted with millions wafted to their shores, have gone through stages of declining political importance, till they now rank with the least prosperous and poorest nations of the civilized world.

The particular sites of metallic and other forms of mineral wealth have been discovered under varied circumstances, frequently in a very accidental manner. A chapter of romantic interest might be written upon this subject. A young florist, in the course of a ramble in South Australia, had his attention arrested by a peculiar appearance on the ground, which might have been mistaken for a plant from its brownish green hue; but on further examination, it proved to be an outcrop of copper, and brought to light the immense stores of the metal which are now worked in that region. California had been visited by travellers, botanical rangers, and an experienced mineralogist from the United States, without anything being known of its gold, concealed in most places by a layer of vegetable soil, till a settler laid open some glittering grains of the treasure in cutting a trench for a mill-race.

History relates, that in the early part of the sixteenth century, an Indian shepherd tended his flocks on a small pampa, near the lake of Llauricocha, in Peru, one of the sources of the mighty Amazon river. Having one day wandered further from his hut than usual, and being fatigued, he made a declivity of the Cerro

de Santiestevan his resting-place for the night, kindled a fire to protect himself from the cold, and lay down to sleep. On awaking in the morning, he was astonished to find the stone beneath the ashes of his fire melted and turned to silver. The shepherd communicated this intelligence to his master, a Spaniard, who immediately repaired to the spot, found indications of a rich vein of silver ore, and made preparations for working it. New veins were discovered by fresh adventurers on the spot, whose settlements and explorings originated the city and mines of Pasco. The original mine, still yielding silver, bears the name of La Descubridora, "the discoverer."

In a similarly incidental way, the knowledge transpired of the great quicksilver mine at Idria, in the Austrian empire. It was not known till the year 1497, when a few coopers inhabited that part of Carniola for the convenience of being near the woods. One of them, having finished a new tub, placed it where some water dripping from the rock might fall into it, in order to prove its soundness. But he was surprised to find it a matter of difficulty to remove the vessel from its site. This was owing to metallic globules, shining, but very heavy, at the bottom of the water. The fact becoming public, surveys took place, which led to the opening of the mines in 1525.

In one of Born's letters to professor Ferber, published in the last century, he gives an account of the discovery of the Nagyag gold mine,

in the mountains of Transylvania, near one of the branches of the Theiss. "A Wallachian, whose name was Armenian John, came to my father, then possessed of a rich silver mine at Csertes, telling him, that as he constantly observed a flame issuing from and playing upon a fissure in the Nagyag forest, he was of opinion that rich ores must be hid underground. My father was fortunately adventurous enough to listen to the poor man's tale, and accordingly he drove a gallery in the ground which the Wallachian pointed out. The work went on some years without any success, and was upon the point of being given up. However, he made a last drift towards the fissure, and there hit the rich black and lamellated gold ores, which were first looked upon as iron glimmer, but appeared what really they are as soon as assayed by the fire." The opinion which led to this favourable result is entirely fallacious, for spontaneously ignited inflammable gases occur quite independently of metallic ores. But it is a persuasion of old standing in mining districts, that flames of light have been seen playing upon the surface, till they have perched upon a vein, resting there for a time, and disappearing—a circumstance not improbably connected with electricity, and referable to the good conducting power of the ore. The Nagyag mine is of interest, as, by analysis of its gold ores, the rare metal, tellurium, was first obtained by Klaproth, in 1782.

Formerly, in Cornwall and other places,

faith was universal in the divining rod, as a means of detecting mineral veins. This was usually a forked twig of hazel, or other fruit-bearing tree, cut in winter, and kept dry, which, being firmly grasped at one end, and carried along, was believed to indicate the site and direction of a vein by the other end being drawn to it. Price was a firm believer in its efficacy; many surprising discoveries have been quoted in confirmation of it; and it certainly would be extraordinary, if, in a district so loaded with metallic products, and intersected with veins, some accidental instances favourable to it could not be cited. The reputation of the magical wand continued unblemished down to the close of the last century, all failures in practice being placed to the account of the rod being improperly made or held. But extended intelligence has now nearly exploded the superstition, though as late as the year 1830, a professional performer of repute resided in Redruth. In a similar manner, the sites of subterraneous springs have been sought, a willow branch being commonly employed. Some suppose that the Phœnicians left the practice in Cornwall, and, however this may be, it is undoubtedly of very ancient date.

In various operations, such as draining land, making roads, and cutting ditches, positive indications of a vein have frequently been met with, though this can only happen where it lies near the surface. Sometimes the tainted and discoloured condition of adjacent springs

has led to the discovery, or the sterility of patches of land impregnated with the contaminated waters. At Dolgelly, in Wales, the peat betrayed the existence of copper, not only by its hue, but on being burned it was found so impregnated with sulphate of copper, diffused through it from springs, that the metal was left in its ashes. The existence of veins, and their actual position, have often been determined from fragments or pebbles of ore in the beds of rivulets, or in the alluvial soil of exhausted water-courses, traced to their origin. This method, of great antiquity in Cornwall, is there called *shoding*, the particles which guide the explorer being termed *shodes*. If, however, the question is confined to the existence of metalliferous veins in a district, the solution of it presents little difficulty to the experienced miner ; but it involves the patient consideration of very varied details, the soundest judgment, and the highest skill, to decide the point, whether the produce is likely to repay the cost of bringing it to the surface.

As property in land almost invariably includes everything beneath the surface, the landowner is lord of the subterranean treasures explored in his fields, except gold and silver, which in this, and most other countries, belong by prerogative to the crown. But their actual production is usually conducted by a company of adventurers, (though this applies more to the metalliferous than the coal districts,) who agree with the owner of the mine for a certain num-

ber of years, paying either a fixed per centage or a certain proportion of the ores raised. The bounds or limits of the mine are commonly marked at the surface, either by stones at intervals, or other indications, within which the ground may be excavated beneath, and the surface used, as far as may be necessary for the effectual carrying on of the works. Perpendicular *shafts* for cutting the vein, raising the ore, or for ventilation, carried to an indefinite depth; *levels* or galleries, driven horizontally on either hand from the principal shaft, and in a descending series along its course, with proper intervals between them, for the further exploration of the mine; and a horizontal excavation, called the *adit level*, by which the drainage is conveyed away to the surface—are the great operations necessary to the working of mines. They involve an immense outlay of capital, present difficulties of construction which require the highest mechanical genius to overcome, and are often executed upon a most gigantic scale.

The expense of sinking a shaft is of course a varying sum, and one that admits of no precise calculation beforehand, as the depth to which it may be necessary to go, the texture of the masses to be penetrated, and the obstacles which may arise to tax the skill of the engineer, are uncertain elements. It frequently happens that springs are tapped, and a fearful influx of water ensues, which must be reduced, and the works secured from further invasion, before they can be resumed. One of the greatest

enterprises of this kind on record was commenced at Wearmouth colliery, near Sunderland, in 1826. At the depth of three hundred feet a spring was reached, which poured water into the shaft at the rate of three thousand gallons per minute. Having conquered this difficulty, and sunk to the depth of one thousand feet, another spring was encountered, but the obstacle being overcome, the sinking was continued several hundred feet lower, when valuable seams of coal were reached, to reward the perseverance of the proprietors. Ten years passed away, and not less than £100,000 were expended before they had any returns.

The consolidated copper mines in Cornwall may be taken as an example of extensive workings. They are situated in the parish of Gwennap, about three miles east of Redruth, along the brow of a range of steep hills, and occupy an area of about eight hundred acres. The total amount of sinking is stated to be more than twelve miles in perpendicular depth, and, including the horizontal galleries, the extent of subterraneous excavation is upwards of sixty miles. Eight very large steam-engines, and about thirty smaller, are employed for drainage and other purposes, which nearly equal the work of four thousand horses, and would be almost equal to that of double the number, if exerted to the full extent. The "great adit," which receives the waters of these mines, and of many others in Gwennap and near Redruth, measures nearly thirty miles in

length, including all the ramifications, one branch of it alone extending upwards of five miles, and penetrating ground four hundred feet beneath the surface. The final discharge is through a valley into the sea near Falmouth.

Works of this description evidence the earnestness and indomitable energy of man in the pursuit of wealth. The reflection forces itself upon the mind, that if these qualities are elicited by the riches, which, however they may promote convenience and command luxury, never can confer permanent happiness, and in a few short years "take to themselves wings and flee away," how ought they to be excited by those treasures of revealed truth, the due apprehension of which is connected with spiritual, heavenly, enduring, and eternal blessedness! It is the evidence of a sound mind to judge of things as they are, to estimate them according to their true character—neither overlooking substantial excellences where they are possessed, nor elevating real insignificance into importance by fictitious advantages—always regarding objects in their relation to the future as well as the present. The line of conduct suggested by this rule is, to labour for the bread that perisheth with honest activity, but at the same time to view the maxims of Divine wisdom, as "more to be desired than gold, yea than much fine gold," seeking to be governed by them with an earnestness which may be illustrated, but not surpassed, by that of those who "dig for hidden treasures." A superfluity

of worldly means may enable their possessor with facility to supply his temporal wants, and officiate in the service of the destitute; but his higher nature finds no contentment in them, while they often prove a snare, are held at an uncertain tenure, and fail for ever in life's last hour. How different, if taught of God, and realizing the promised help of the Holy Spirit, the "unsearchable riches of Christ" are apprehended by a true faith in him! Then, indeed, is good secured; the soul finds a resting-place, a source and a centre of delight; the great question of its eternal destiny is decided; and the allotment of poverty and sorrow in this life is cheerfully embraced in the prospect of a blessed immortality.

CHAPTER III.

THE MINERAL KINGDOM.

Animate and inanimate nature—Structure of the surface—The soil—Underlying masses—Series of strata—Results of observation—Mineral substances—Their physical or external characters—Chemical or internal characters—Elementary substances.

The term mineral, as now used, has a signification much extended beyond its original limits, as it is applied to every part of the globe which is not animal or vegetable, to all inorganic natural objects, whether solid, liquid, or gaseous. If the productions of this class, which nature has unfolded in "dens and caves of the earth," or which have been disclosed by mining processes, have not yet become a branch of general study, it is not because they are deficient in importance and interest, but owing to the subject offering difficulties to popular apprehension, and to the ordinary channels of information concerning it being commonly abstruse technical works. It is true, however, that other objects of the external world, included in the animal and vegetable kingdoms, awaken sympathy and invite attention, by attributes and attractions which are wholly wanting to the mineral.

The departments of zoology and botany include beings endowed with the wonderful and incomprehensible principle of vitality, which increase by the assimilation of nutritive substances taken internally, arrive at maturity by a series of successive developments, and are surrendered to decomposition upon the extinction of the vital energy. Life, and its manifestations, the power of motion, and the evidences of growth, give to animate objects a strong hold upon the mind, and lend a peculiar charm to their investigation, while a practical acquaintance with their forms conducts the student into agreeable scenes—to the woods, where the feathered songsters flit from bough to bough—to the fields, where gorgeous insects sport in the summer's sun—and to the streams, which murmur to the wild flowers on their banks. It is otherwise with the constituents of the trodden earth. While separated from the departments of living nature, and perfectly inert, they are frequently of dull, rugged, and unpromising appearance, and are often only to be contemplated in position by a fatiguing exploration of the rudest wilds, or by penetrating to damp and chilling subterranean sites, never visited by the warm sunbeams nor reached by the light of day, and with difficulty rendered accessible to refreshing supplies of the external air.

Still, these inanimate substances have peculiar and high claims to attention. In some instances, outward grace is exhibited in brilliant colour-

ing and symmetrical shapes, regularly formed crystals being presented, comparable in the mineral kingdom to flowers in the vegetable. Other materials of the solid globe are indispensable to the useful arts, contribute largely to the convenience of man and the refinement of society, and are, in fact, so necessary to the higher purposes of existence, that a knowledge of their qualities, and their use as agents, constitute one of the distinctions between barbarous and civilized life. Indeed, as acquaintance extends with the still and lifeless elements of nature, the evidence of the great truth accumulates, that not only has almighty power operated in the creation, but infinite wisdom and goodness; and thus the very stones remind us of our obligations to "give unto the Lord the glory due unto his name," the true end and legitimate aim of all scientific inquiries.

Commencing an examination of the earth with the surface, we meet with a stratum of soil, of very variable thickness, which forms its external vestment or outer garb, except in mountainous regions, where the hard and naked rock protrudes. The soil is composed generally of materials derived by decomposition from subjacent stony masses, or brought down from the sides of hills by the action of running water, and transported to a distance from the original bed. Several distinct substances become commingled by this process, aiding fertility, the whole being further altered by vegetable admixtures. In some localities, exposed

to the transporting power of water, or where clays and soft sandstones occur, this superficial covering exhibits considerable depth, but over chalk it is always thin, frequently amounting to only a few inches in thickness. Immediately below the soil, in most countries, aggregations of sands, clays, or gravel, are found, or a mixture of them, extending to a depth of from ten to a hundred feet or more; but in some districts, masses of a rocky consistence are at once arrived at. Beneath the looser deposits, which bear to the skeleton of the globe much the same relation as the flesh to the bones in the animal frame, solidified materials appear, usually arranged in beds or layers, of varying hardness, texture, and thickness, and of different kinds in different countries, or in different places of the same country, and in the same place according to the depth. The following strata are enumerated as having been passed through in the Newcastle coal-field, in order to reach workable seams of coal in Bigge's main colliery :—

	Feet.	Ins.
From the surface of the ground they sank through clay to the depth of . . .	102	0
Through sandstone	42	6
They then came upon the first seam of coal, but which had only a thickness of . .	0	8
From this seam to the thick bed called the High Main coal of the Tyne, they sank through twenty-nine different beds of sandstone and shale, varying in thickness from forty inches to thirty-one feet, interstratified with eight seams of coal, from five to eighteen inches thick, amounting together to	418	2
Carried forward . . .	563	4

	Feet.	Ins.
Brought forward . .	563	4
The High Main coal of the Tyne had here a thickness of	6	8
From this seam they sank further through fifty-two beds of sandstone and shale, varying from five inches to thirty-four feet in thickness, interstratified with nineteen different seams of coal, from two to thirty-seven inches thick, and amounting together to	503	2
They now came upon the seam of coal called the Low Main coal of the Tyne, which had in this pit a thickness of	2	9
And they sank beneath this through ten different beds of stone, from twelve inches to twelve feet thick, and two seams of coal of four to twelve inches, making together	82	0
	1,157	11

Thus, in descending a total depth of 1,158 feet, 125 different strata were successively passed through.

Actual penetration of the surface—observation directed to the slopes of mountains, the sides of ravines, precipices, and sea-cliffs—together with that fine and benevolent arrangement of the Creator, the subjection of strata to upheaving forces, by which some of the more useful portions have been raised from depths inaccessible to man, and brought within the range of his inspection—reveal the fact, that different kinds of matter, or mineral substances in immense variety, compose the exterior parts of the earth. The masses of compact rock which meet the eye, towering to the clouds, or lie buried beneath a load of loose superficial accumulations, consist of various compounds or mineral aggregates. Sometimes, indeed, though

rarely, a simple mineral alone enters into their composition, as quartz, which forms extensive masses. But, in general, two or more species appear in intimate combination. Thus, granite has for its constituents the three minerals, quartz, feldspar, and mica, which, varying in their proportions, originate quartzose, feldspathic, or micaceous granite, according to the predominating material. These are called *simple* minerals, in contrast with the mighty masses formed by their aggregation, though they, and almost all others, are really compound substances. In fact, the simple minerals, understanding by that expression those which are not resolvable by chemical processes into various elements, include only a small number of the metals, which are sometimes found pure.

Minerals are discriminated by the possession of certain characters, an acquaintance with which is necessary to the task of recognition. But to be capable of identifying them on inspection is an attainment which no written description of their properties can convey. It is only to be arrived at by practical observation and long experience. Nevertheless, a knowledge of their leading characteristics is an indispensable auxiliary. The first class embraces those which, being more or less obvious to the senses, are termed physical or external; the second class includes those which scientific experiment is needed to reveal, therefore styled chemical or internal.

Physical or External Characters.

Touch.—A few minerals indicate their nature when handled by peculiar impressions upon this sense, as *soap-stone*, which is unctuous to the touch, and has been so called in consequence; and *chalk*, which feels dry and meagre, neither soft nor harsh.

Taste.—This character belongs only to soluble minerals and liquids, and is very important in distinguishing them. The different kinds of taste noticed, with examples of them, are as follows: astringent, *vitriol;* sweetish astringent, *alum;* saline, *common salt;* alkaline, *soda;* cooling, *saltpetre;* bitter, *Epsom salts;* sour, *sulphuric acid.*

Odour.—Except some of the gases and soluble salts, minerals do not give off any odour in a dry, unchanged state; but it may be elicited, of various kinds, from many, by a forcible stroke, by friction, by moistening their surfaces with the breath, and also by the application of heat or acids.

Adhesion to the tongue.—A species of slate, found in the gypsum around Paris, strongly betrays this property, and has hence received the name of *adhesive slate.* It is observed also in *lithomage* and a few other substances; but this and the preceding character are not of common occurrence.

Lustre.—While some minerals are marked by a total absence of this quality, in which case they are said to be *dull*, others strikingly dis-

play it, owing to their surfaces reflecting more or less of the light incident upon them.

There are different kinds of lustre exhibited, arising from the varying nature of the reflecting surfaces. They are named from some familiar object, or class of objects, in which they are conspicuous. Hence the metallic lustre, or that of the pure *metals;* the vitreous, that of broken glass, the most common lustre in the mineral kingdom, seen in *quartz;* the resinous, of which *opal* and *amber* are examples; the pearly, displayed by *talc*, *native magnesia*, and *pearl-spar;* the silky, observable in *malachite*, *satin-spar*, and minerals of a fibrous structure; and the adamantine, or lustre of the *diamond.*

There are also different degrees of lustre, arising from variations in the quantity of light reflected. The degrees of intensity are discriminated by the following terms: splendent, when light is reflected from the surface with great brilliancy, and a well-defined image is given, of which *Elba iron ore* and *tin ore* afford examples; shining, when an image is produced but not well defined, as in the instance of *calcareous spar;* glistening, when there is a general reflection from the surface, but no image, as with *talc* and *copper pyrites;* and glimmering, when the reflection is very imperfect, as with *flint* and *chalcedony.*

Transparency.—This property, or the capability of transmitting the rays of light, varies greatly in the mineral kingdom, and even in different specimens of the same substance. A

mineral is said to be transparent when the outline of an object is distinctly seen through it, as, for instance, *rock crystal*, used as a material for spectacle-glasses; semi-transparent, when the object is seen, but the outline is not distinct; translucent, when no object is seen, but light is transmitted, as *Carrara marble;* and semi-translucent, when light only is partially transmitted. The metals, and a few other minerals, are perfectly incapable of transmitting light, and are hence termed *opaque.*

Double refraction. — In addition to being transparent, a few minerals possess the power of producing two images of an object viewed through them, one observed by the usual refraction of the light, and another perceived by means of an extraordinary refraction. This property is best exhibited by that variety of carbonate of lime, called in consequence of it, *doubly-refracting spar* and *Iceland spar*, from being first obtained in that island.

Colour.—The external hue is not an important character in distinguishing minerals, since it is often very different in the same substances, owing to the accidental presence of foreign ingredients, in a degree so slight as not to alter the composition of the mass, while causing superficial varieties of colour. That which is presented by the fine powder produced when a mineral is abraded with a file, and by its mark, or streak on paper, is a better guide, as it seldom varies in the same species.

The appearance of colours changing in rapid

succession on turning a mineral, is a property which belongs in perfection to the *diamond*, and is also observed in *precious opal*, most conspicuously by candle-light. In other instances, crystals present different colours when viewed in different directions. This property, termed *dichroism*, "two colours," exists in *tourmaline* and *mica*.

Phosphorescence. — The emission of light distinguishes some of the mineral species when exposed to friction or to heat. Sparks are readily evolved from *quartz* upon two pieces being sharply rubbed together; and even a feather, rapidly moved across some specimens of *sulphuret of zinc*, will often elicit light from it. Subject to a high temperature, *fluor spar* becomes beautifully phosphorescent, a variety of it, called *chlorophane*, signifying brilliant green, giving out a splendid emerald-coloured light.

Flexibility.—The capability of being bent into any form without being broken, and of retaining the form forcibly given, is distinctive of a few minerals, *talc* and a *phosphate of iron* found in Cornwall.

Elasticity.—Other minerals capable of being bent resume their former position upon constraint being withdrawn. This elasticity belongs to *mica* in a high degree, and distinguishes it from the simply flexible *talc*.

Frangibility.—The ease with which a mineral may be broken varies greatly in different substances. Some are readily separated into

fragments by the knife; others yield only to a blow with the hammer; others, again, under great mechanical force, do not separate into fragments, but the mass thins and spreads out; and all intermediate degrees of frangibility exist, from the most brittle to the toughest masses. *Sulphur*, *fluor*, and *calcareous spar*, are readily broken in almost every direction; while the *topaz*, *sapphire*, and others, yield to cleavage easily in one direction only, and with extreme difficulty in any other. In the former case, frangibility seems to be independent, to some extent, of any arrangement of the component parts; and in the latter, to depend upon it.

Fracture.—When crystalline minerals are divided in directions contrary to the natural joints, and those which are amorphous, or without regular form, are broken, the surfaces present various kinds of fracture. It is said to be conchoidal when the mineral breaks with concavities resembling the valve of a shell, and hence the name, from *concha*, a shell, of which *flint* offers an example; even, when the fractured surface is nearly flat; uneven, when it shows elevations and depressions; and hackly, or splintery, according to the character of the irregularities.

Hardness.—This quality varies from the softness of *bitumen* to the hardness of the *diamond*. Minerals are discriminated as to hardness by attempting to scratch one with another, or by trying each with a file. But

chiastolite and *sapphire* are examples of a low degree of hardness being given under the file, owing to impurities, or imperfect aggregation of the particles, while they scratch a harder species, showing that the particles are hard, though loosely aggregated. Some crystalline minerals, *kyanite* and *mica*, present different degrees of hardness on dissimilar faces.

Specific gravity.—Two different minerals of equal dimensions generally disagree in weight, which becomes a highly useful discriminating character, since it may be ascertained with precision, and ranges within narrow limits in minerals of the same species. The weight of one substance being considered as unity, the proportionate weight of another of the same volume is termed its specific gravity. This comparison is usually made with water in the case of solids or liquids, and with atmospheric air in the instance of gases. Thus, if a cube of mineral matter weighs twice or three times as much as a similar cube of water, its specific gravity will be represented by two or three, as the case may be.

Magnetism.—One of the ores of iron alone exhibits the remarkable property of magnetic polarity and attraction, and has hence been styled *magnetic iron ore*, *natural magnet*, or *native loadstone*. This ore, a variety of oxide of iron, when arranged in the form of a horse-shoe, displays the property strongly, and will lift heavy weights. But several of the ores of iron, though not possessed of magnetic powers

themselves, are attractable by the magnet, with a few other metals, as *cobalt* and *nickel*.

Electricity. — A considerable number of minerals develop electric properties by friction, as *amber*, which, if rubbed with a cloth, will attract a hair placed at a short distance from it; and some exhibit electric polarity on being subjected to heat, as *tourmaline* and *boracite*. From experiments made on the power of minerals to conduct electricity, it has been shown, that the native metals are the best conductors, next the sulphurets, and next the oxides; that lustrous metallic crystals are good conductors, and unmetallic crystals in general bad conductors; that the diamond conducts electricity badly, while the opposite quality is displayed by *graphite* and *anthracite*.

External form.—Many of the inorganic productions of nature present themselves to attention without any determinate form, and are hence said to be amorphous; while others exhibit the peculiarity of regular and symmetric shapes, due to a power called crystallization, under the action of which their particles assume the geometrical figures observed. This power in the mineral kingdom is strikingly analogous to that of vitality in the animal and vegetable, from whence arises the variety of structure apparent in animals and plants, while there is the same structure, as to plan and system, in the same species, with endless modifications of subordinate details in the individuals. So it is equally true, that while crystals of the same

mineral vary greatly in size and shape, there is a certain form, distinctive of the species, called primitive, of which they are modifications, because they are all reducible to it. It is a fundamental law in crystallography, that "the same mineral presents uniformly the same primary form as the basis of its crystallization, and when crystallized, exhibits this primary, or some secondary to it," wherever it may be collected, in the heart of Asia or across the Atlantic. Thus, *carbonate of lime* occurs naturally crystallized in numerous varieties of form, stated at eight hundred, all of which are reducible to the rhomboid, none showing any connexion with the cube. It is thus apparent, that while the forms of crystals seem to superficial observation the accidents of nature, they display, on intimate acquaintance, the operations of laws appointed by the Divine power and wisdom, as much as the spheroidal masses of the planets and the circular paths in which they move.

A crystal is a geometrical solid, bounded by symmetrically-arranged plane surfaces, which are called its faces, the particles having assumed determinate form under control of some law of attraction or affinity. Originally, the term crystal, derived from a Greek word signifying *ice*, was applied only to crystallized quartz, which the ancients believed to be water congealed by great intensity of cold.

Six principal simple, or primary forms of crystals, are noticed.

The regular tetahedron—having four equilateral triangles for its faces, a form commonly seen in *blende* and *copper pyrites*.

The cube—having six equal squares for its faces, very perfectly seen in *iron pyrites* and *fluor spar*.

The dodecahedron—a solid of twelve faces, each being a rhombus, the usual form of *common garnet*.

The octohedron—bounded by eight triangular faces, observed in *spinel-ruby*, and, with varieties, in numerous substances.

The hexagonal prism—the form of *beryl*, *emerald*, and generally of *quartz*.

The rhomboid—a solid of six faces, differing from a cube, in having only its opposite sides equal, observed in *Iceland spar*.

To these, and a few other primary forms, all the varieties of shape presented by crystals may be supposed to be reducible, either by the addition or subtraction of definitely-arranged particles.

Crystals of the same mineral occur of all sizes, from minute, and even microscopic points, to masses of some feet in circumference. Regular dodecahedrons of common garnet, of several pounds' weight, have been obtained in various localities. A cavity, opened about a century ago at Zinken, afforded enormous rock-crystals, one of which weighed eight hundred weight, while others varied from four to five. In the British Museum there is a specimen upwards of a foot in length, with a propor-

tionate diameter; and there is another now at Milan, three feet and a quarter long by five and a half in circumference, estimated to weigh eight hundred pounds. Beryls of nearly equal dimensions have been found in the United States; but these large specimens never have the perfection and transparency observed in those of small size. Beautifully and truly has crystallization been pronounced "a peculiar and most admirable result of nature's geometry," worthy of being studied with all the power of genius, not only on account of the delight which always attends the perception of symmetric proportions, and the knowledge of wonders, but because it reveals, as much as any other department of the material world, the infinite resources of its Divine Author.

Chemical or Internal Characters.

The internal properties of minerals refer chiefly to the materials which enter into their composition. They are not, like the external characters, open to observation, but are ascertained by analysis, which, except in a few instances, the accomplished chemist is alone competent to conduct. It would be quite out of place in these pages to refer to the methods employed in order to define the number and nature of the ingredients which combine in mineral objects. But the great result obtained from the processes of the laboratory may be stated; that in the vast and diversified host of bodies which nature presents to our attention,

analytical researches have only discovered some sixty substances, which form, by their varying proportions and modes of combination, the entire phenomena of the inorganic world. These substances are styled *simple* or *elementary*, being found to be incapable of further analysis, in the present state of our knowledge.

There is no known body which contains all the substances referred to, or even a majority of them, but the greater number of bodies are made up of two, three, four, five, or six ingredients. Some of the simple substances also occur very rarely, while others enter largely into the constitution of the globe. Their relation to the objects they combine to form, has been aptly compared by professor Wilson, (the substance of whose illustration may be given,) to that which subsists between the letters of the alphabet and the words they compose. Every English word is a compound of two, three, four, or more letters, into which it may be analysed; but the twenty-six letters themselves admit of no analysis, and are the primary elements out of which the language is constituted. But certain of these letters occur much more frequently in words than others. Thus, the vowels and some of the consonants are profusely used, while the letters Q, X, and Z, enter into the composition of but few terms. The case is precisely parallel in the mineral kingdom; its simple substances correspond to the letters of the alphabet, some occurring rarely, while others are very abundant; and the bodies

they unite to form correspond to the words constructed of the letters, which are more numerous in some than in others. Thus, water, a compound of two elements, oxygen and hydrogen, may be compared to a word of two letters; marble, formed of three elements, calcium, oxygen, and carbon, to a word of three letters; and alum, composed of four elements, aluminum, potassium, oxygen, and sulphur, to a word of four letters.

Of the sixty simple substances, there are only about sixteen of importance, on account of their extended occurrence; these are mentioned in the three following classes, according to their amount, the first in each class being most abundant:—

Metalloids, or the bases of the earths and alkalies. — Silicium, aluminum, potassium, sodium, magnesium, calcium.

Metals proper.—Iron, manganese.

Non-metallic substances.—Oxygen, hydrogen, nitrogen, carbon, sulphur, chlorine, fluorine, phosphorus.

With the metalloids and metals, oxygen enters so generally into combination, and in such large proportions, that it has been calculated to compose fifty per cent., or half of the ponderable matter of the globe.

The astonishing nature of these facts can in some degree be appreciated by the untutored individual, however unacquainted with appearances below the surface upon which he treads, or with the grander characteristics of the foreign

landscape, and however his range of observation may have been confined to the acres around his native homestead. Yet more competent as is the cultivated and enlarged mind to grasp the marvel, it utterly fails to realize impressions at all commensurate with the striking reality, that out of a few elements, the vast and richly-varied results presented by the mineral kingdom have been constituted. Simple admiration is not, however, the only feeling which material arrangements are designed and adapted to excite; but adoring reverence to Him "who only doeth wondrous works," and to whose "eternal power and Godhead" nature offers a silent, but emphatic demonstration, in disclosing simplicity of means contributing to the production of endless diversities.

> "Oh! wisdom truly perfect! thus to call
> From a few causes such a scheme of things,
> Effects so various, beautiful, and great."

Nor do the inorganic parts of creation less strikingly evidence the adaptation of external nature to the wants and convenience of man than its living forms. That Being who called into existence the animal tribes adapted for his use, and "causeth the grass to grow for the cattle, and herb for the service of man: that he may bring forth food out of the earth," has rendered its inert masses auxiliary to his welfare, for they compose the materials of his dwelling, form his most necessary and useful implements, supply valuable medicines to him in pining sickness, and furnish ingredients, without

which the staple articles of food would not preserve life in health and vigour. The arrangements of the material world thus illustrate the care of God for the welfare of mankind, so gloriously evidenced by the dispensations of his grace; and we may be admonished to a thankful recognition of the Divine goodness, and a wise improvement of it, by the recollection, that nature and revelation alike harmoniously proclaim his power, to vindicate the authority of his government, and punish the ungrateful despisers of his will.

CHAPTER IV.

EARTHY, ALKALINE, AND ACIDIFEROUS MINERALS.

Earthy minerals — Alkalino-earthy minerals — Acids — Acidiferous earthy minerals—Acidiferous alkaline minerals—Acidiferous alkalino-earthy minerals.

It will not be within our limits to notice the immense variety of objects which the title of this chapter embraces. It is the less necessary to do so, as these pages are not designed to form a manual of mineralogy, but simply to convey a measure of information upon the subject, awaken interest in the intelligent mind, and suggest a useful branch of study, for the further prosecution of which our literature supplies many admirable aids. Some selected specimens will alone be given of those species which claim attention from their beauty, or importance to man, or their particular uses. In the following classification, the arrangement of Mr. W. Phillips, founded upon chemical composition, is adopted.

Earthy Minerals.

This division includes those substances in which the earths appear uncombined with

alkalies or acids. The earths which enter into the composition of minerals are ten in number, but only the four first-named occur to any important extent. They are as follows :—

1. Silex.	4. Magnesia.	7. Glucine.	9. Yttria.
2. Alumine.	5. Barytes.	8. Thorina.	10. Zircon.
3. Lime.	6. Strontian.		

These substances are not simple, but compound. Thus, silex is an oxide of silicium, or the element so called, in combination with the air or gas oxygen ; and all the rest are metallic oxides. Though sometimes found isolated, in general two or three of them are associated in different proportions.

Silex.—This is one of the most abundantly diffused substances in nature, a prime ingredient of many serviceable minerals, and also of several ornamental or precious stones, long employed in jewellery, imparting to them their hardness. Taking those forms of the useful kind in which it appears first in order, we commence with *quartz*, which is nearly pure silex. The name of this mineral is of unknown origin and meaning. It is found massive, forming extensive beds ; crystallized, exhibiting numerous diversities ; and contributes also as an ingredient to the formation of the firmest rocks, granite and gneiss, so important for architectural and other purposes. One of the most familiar forms under which it is exhibited is *flint*, abundant in the chalk districts, and well-known from its former universal use in household life, owing to the capability of strik-

ing fire with iron, a property which belongs more or less to most siliceous bodies. Upon the sharp edges of a flint being struck against a piece of soft iron, minute particles of metal are detached, which are fused into momentary sparks, sufficient to inflame tinder. This was the ordinary mode by which our fires were lighted before the invention of the lucifer match. In a similar manner, sparks are often observed struck by a horse in rapid motion, caused by the collision of his iron shoe with the flints on the road. Gun-flints act in precisely the same way.

The most important service rendered to mankind by these minerals is the production of glass. Siliceous matter being naturally incombustible, the masses into which it enters largely furnish good firestones, or stones capable of sustaining a powerful heat; but it readily fuses when mixed with an alkali, and runs into glass, the more transparent according to the purity of the material. Nature has largely aided the glass-maker in the manufacture, saving him the expense of grinding down its siliceous masses, for that operation has already been performed, the sands of the sea-shore, and of other sites, being quartz or flint in a state of disintegration. The pure white sands of Alum Bay, in the Isle of Wight, of the coast of Norfolk, and of some inland localities, make the finest kinds of glass, coloured varieties resulting from the use of metallic oxides. Green glass is produced by the oxide of chrome; yellow, by the oxide of

antimony; blue, by the oxide of cobalt; and black by the same, mixed with the oxide of manganese.

A singular circumstance respecting flint is its distribution in regular parallel layers through the chalk rocks, examples of which may be seen in the Dover cliffs, where they may be traced continuously for several miles. Something similar to this takes place in the manufacture of porcelain, in which flint and clay are used, pounded extremely fine, and reduced to a common semi-fluid mass by water. If the mass thus formed is suffered to remain tranquil a sufficient time, the flint will separate from the clay, and affect a particular grouping, analogous to that which it naturally exhibits in the chalk.

The series of the *clays*, an extensive class, showing almost every diversity of colour, texture, and hardness, belong to the family of siliceous minerals, some of the other earths, in smaller quantities, appearing in their composition. There are few substances more useful than the common clay, made into bricks, the ordinary material of our dwellings; other forms of it are employed in the manufacture of tiles and pottery; and several peculiar varieties are of high importance. *Porcelain-clay*, used in the production of the finer kinds of earthenware, results from the decomposition of one of the constituents of granite, and is hence obtained from granite districts. China possesses an abundant supply of admirable quality, one

reason of its superiority in the manufacture. A large tract occurs near St. Austle, in Cornwall, which is worked for the supply of our own potteries; but a considerable quantity is obtained by artificial means from the granite, and many thousand tons of both kinds are annually shipped from the south-west of England to the sites of porcelain production. *Fullers'-earth*, valuable from its property of removing by absorption oily matter, and used for this purpose in domestic economy, is a species of clay, found in beds in many countries, and abundantly in various parts of our own, the county of Surrey yielding a large supply.

Indurated clays, of that peculiar structure which admits of the material being split into thin layers, take the name of *slates*, from whence we have roofing-slate, slabs for paving, and the implements of the schoolboy—his slate and pencil. The varieties occur in enormous masses in various regions. They rise to great importance in the south of Ireland, in North Wales, and in the English lake district, forming the most elevated points of land in the last-named locality, as in Skiddaw and Sca-Fell. Extensive workings are there conducted for roofing-slate, at the height of two thousand feet above the lake of Buttermere; but the largest quarries are at Penrhyn, in the neighbourhood of Bangor. The strata have here been cut away to the extent of upwards of two thousand feet in length, nine hundred in breadth, by nearly three hundred feet below the natural surface. Blocks

which will not readily split are frequently used for building. The town of Angers, in France, is roofed and mainly built of this material.

Some ornamental or precious stones of the siliceous class may now be noticed. *Rock crystal*, referred to in the preceding chapter, of frequent occurrence in all mountainous districts, is the purest specimen when perfectly transparent. But far more beautiful is the *amethyst*, with its clear purple or bluish-violet colour, the finest examples of which come from India, Ceylon, Siberia, Persia, and Spain. Pliny speaks of it as cut and polished by the ancients for rings and combs. They were fond of having it about their persons, owing to its supposed virtues, to one of which, that of protecting the wearer against intoxication, the name refers, derived from *a*, not, and *methuo*, to intoxicate. Differing only in colour, a rich light yellow, is the *cairngorm stone* of our own country, named from its locality, one of the Grampian mountains, where splendid specimens have been found; it is often styled the false topaz, from its resemblance to that mineral.

But slightly removed from the preceding in composition, is *precious* or *noble opal*, a gem of great beauty and value, remarkable for its brilliant interchange of colours, which is chiefly obtained from Hungary. In *chalcedony*, named from the city of Chalcedon, where it was collected by the ancients, a small portion of alumine appears. This mineral is widely distributed, occurs in several forms, but is never found crystallized.

It is not uncommon in some parts of Great Britain, but Iceland and the Faröe Islands are its famed localities. The following are varieties of it: *onyx*, white, and *sard*, brown chalcedony, forming *sardonyx* when associated in alternate layers; *chrysoprase*, signifying the "leek-green stone," a rare and highly prized example, tinged with an apple-green; *carnelian*, of a flesh colour, and hence so called; and *agate*, a generic name for several species of variegated stones. *Moss agate* presents apparently vegetable impressions; *fortification agate* is maked with zigzag lines, like the angular outlines of a fortress; *ribbon agate* has alternating bands of different hues; and *Mocha-stone*, chiefly brought from Mocha, in Arabia, exhibits various delineations and colours. The agate, or *achates* of the Greeks, received its name from that of a river in Sicily, whence the first samples of the stone were brought to them. It is often made into mortars for the compounding of drugs, and for chemical purposes, and was so employed, according to Pliny, by the medical practitioners of his time. The royal collection at Dresden contains a complete table-service entirely composed of it. The *jaspers*, frequently formed into vases, are closely related to the agates, but more opaque. Egyptian, or brown jasper, is afforded abundantly on the borders of the Nile; pebbles of red jasper strew the plains of Argos; a yellow variety is found in the vicinity of Smyrna; and a striped species is met with in Siberia, Saxony, and Devonshire.

While of necessity overlooking a number of interesting objects, an addition may be made to the enumeration given, of the *precious garnet*, generally supposed to represent the *carbuncle* of the ancients, and highly valued as an ornamental stone. It has a bright red colour, of various shades, sometimes accompanied with blue or yellow tints. The Burman empire, Ceylon, and Greenland, supply it in the greatest perfection. As a considerable proportion of alumine enters into its composition, while silex is the chief ingredient, it naturally leads us to the class of earthy minerals, in which silex is subordinate and alumine predominant.

Alumine.—This is also a very abundant earth, ranking next, in this respect, to silex; but it never occurs pure in nature, and is only to be obtained by artificial processes. Though entering into the composition of a vast number of bodies, some of which have been mentioned, it is only in comparatively few so far predominant as to be characteristic, and will require but a brief notice. All the clays contain it; few soils are free from it; and it appears as an ingredient in rocks and strata forming the largest mountain-chains of the globe. But, except when in alliance with an alkali or an acid, it is chiefly confined as a prime constituent to some precious stones.

The *sapphire* is the purest form of alumine, the other ingredients amounting to a very small per centage. This highly-valued gem is, next to the diamond, the hardest substance in nature.

It varies in colour, but is commonly blue, of different shades, from deep indigo to pale azure. An evident reference to this colour is made in the book of Exodus, for when Moses and Aaron went up into the mount, "they saw the God of Israel: and there was under his feet as it were a paved work of a sapphire stone, and as it were the body of heaven in his clearness," xxiv. 10. The Greeks, from whom we have the name of sapphire, applied it to a blue stone, the description of which more exactly answers to the substance which yields our ultramarine. The finest sapphires are obtained from Ceylon. A crystal, formerly belonging to the *Jardin des Plantes*, at Paris, realized the sum of three thousand pounds; but the *oriental ruby*, the same gem in all respects but colour, which is a rose or blood-red, according to the name, (*ruber*, red,) commands a far higher price, and rivals the diamond in value. The best rubies come from the Burman empire, but smaller individuals are found in Bohemia, and in the sand of the Expaillie river, in Auvergne. *Corundum*, abundant in the East Indies, and *emery*, found in masses in the Greek Archipelago, are impure species of sapphire, employed, when reduced to powder, in polishing glass, marble, steel, and other metals. In the *topaz*, a very varying gem, silex occupies a conspicuous place, though subordinate to alumine. The name is derived from a Greek term, signifying *to seek*, and was applied to an island in the Red Sea, where the ancients met with the product, but which being

often surrounded with fogs, was difficult to find. The largest and finest topazes come from the Ural and Altai mountains, Kamschatka, and other parts of Siberia; splendid crystals have been collected in the Cairngorm district of the Grampians; and small imperfect specimens are met with at St. Michael's Mount, in Cornwall, and in the Mourne mountains of Ireland. The great topaz in the museum of St. Petersburg measures nearly five inches in length and breadth. That this stone was highly prized in antiquity may be concluded from the saying ot Job respecting wisdom, "The topaz of Ethiopia shall not equal it."

Lime.—This well-known material, so important in the operations of agriculture, and useful in the formation of cement, occurs only in combination with an acid. The calcareous minerals, therefore, which it contributes to form, are noticed in the section devoted to the acidiferous class. The remark applies also to the earths, barytes and strontian.

Magnesia.—This substance, familiar from its medicinal properties, appears with other ingredients in various minerals, and combines to form extensive masses, but is not conspicuous as a leading constituent. It occurs in *serpentine*, of which there are two species, each offering varieties. *Noble serpentine*, a beautiful translucent product, has a rich pale oil-green colour, often marked with bright red tracings. It forms an admirable material for ornamental in-door work, slabs for tables, panels, and vases,

the more highly prized from fine specimens being rare. They are chiefly obtained in this country from the neighbourhood of Portsoy, in Aberdeenshire, a locality which contributed to adorn the palace of Versailles. *Common serpentine*, dark-coloured and opaque, occurs in masses at the Lizard Point in Cornwall, and in many other places. The gem *chrysolite*, brought from the Levant, is chiefly magnesian. The name, meaning "gold-stone," refers to its appearance.

Glucine.—This earth very rarely occurs, but forms a component of some of the finest gems. It appears in *chrysoberyl*, "golden beryl," an allusion to its colour, chiefly found in Ceylon and Brazil. *Alexandrite*, a mere variety, from the Ural mountains, received that name from having been discovered on the birthday of the emperor Alexander, and from showing the Russian colours, green and red. *Beryl* contains the same ingredient, the crystals of which being frequently, as Pliny describes them, "green like the sea," or showing beautiful shades of blue, were hence termed by the Latins, *aqua marina*, "sea-water." Siberia, India, and Brazil, furnish fine and large specimens; but one of the most remarkable localities for inferior examples of gigantic dimensions is Acworth, in the United States. One hexagonal prism from this place weighed two hundred and forty pounds, and measured four feet in length by two and a half in circumference. *Emerald*, among the richest of gems, and one of the softest, is the same

mineral as beryl, only distinguished from it by colour, an inimitable green, supposed to be derived from a minute quantity of the oxide of chrome.

The remaining earths appear only in a few minerals, which call for no remark, being wholly unimportant. But the *hyacinth*, which contains zircon, and is found in the sands of rivers in Auvergne, Bohemia, Transylvania, and other districts, may be simply mentioned, as being sometimes cut as a gem, and from the ancients being acquainted with a precious stone of that name.

As there will be little further occasion to refer to the gems, the first historical notice of several which have been mentioned may here be introduced. It occurs in the description given of the official costume of the Jewish high-priest, and is of interest as showing that, at the time of the Exodus of Israel, many of the prized mineralogical forms of the present age were known and valued, while proficiency had been acquired in the lapidary art. The passage refers to the breast-plate: "Thou shalt set in it settings of stones, even four rows of stones: the first row shall be a sardius, (carnelian ?) a topaz, and a carbuncle: this shall be the first row. And the second row shall be an emerald, a sapphire, and a diamond. And the third row a ligure, (hyacinth ?) an agate, and an amethyst. And the fourth row a beryl, and an onyx, and a jasper," Exod. xxviii. 17–20. The same enumeration is made, xxxix. 10–13,

when the execution of the breast-plate is stated, according to the plan prescribed. Nine out of the twelve precious stones here mentioned are specified by the prophet Ezekiel, as worn by the king of Tyre, those omitted being the ligure, agate, and amethyst. A list of twelve gems is again given at the close of the inspired volume, where a striking picture is drawn of the New Jerusalem: "And the foundations of the wall of the city were garnished with all manner of precious stones. The first foundation was jasper; the second, sapphire; the third, a chalcedony; the fourth, an emerald; the fifth, sardonyx; the sixth, sardius; the seventh, chrysolyte; the eighth, beryl; the ninth, a topaz; the tenth, a chrysoprasus; the eleventh, a jacinth, (hyacinth;) the twelfth, an amethyst," Rev. xxi. 19, 20. Here some of the most splendid and highly-prized objects with which the senses are conversant have been selected as images, feebly to express the indescribable glory of the heavenly world. To awaken serious thought, and guard from the delusive paths of sin, the monitory passage appended to the same picture may be appropriately quoted: "There shall in no wise enter into it anything that defileth, neither whatsoever worketh abomination, or maketh a lie: but they which are written in the Lamb's book of life."

Alkalino-Earthy Minerals.

The objects embraced in this class consist of those in which some of the earths appear com-

bined with one or more of the alkalies—mainly potash and soda.

Potash.—This alkali is one of the ingredients of *mica*, along with silex and alumine. The mineral, mica, is a constituent of granite and its associate rocks, gneiss and mica-slate. It has a lustrous appearance, and hence its name, from the Latin, signifying *to shine*. In parts of the Russian dominions it occurs in extensive masses, which, admitting of being split into thin transparent plates, are used in Siberia for windows, and are commonly called Muscovy glass. But its transparency is speedily marred by exposure, rendering it a poor substitute for the product of art in general use. It is employed in the same way in the Russian navy, as less liable to fracture from the concussion produced by the discharge of heavy artillery. *Feldspar*, or field-spar, a name received from the Germans, perhaps alluding to its exposure at the surface in some parts of the country, contains the same alkali, with lime in addition to the earths named. It is also an essential ingredient of granite, and occurs independently in various forms. *Soap-stone*, with its variety, *steatite*, a name derived from the Greek for soap, alluding to its unctuous feel, has the alkali in alliance with silex and magnesia. It occurs at the Lizard and in other parts of Cornwall, and contributes to the manufacture of porcelain. Some of the Arabs are reported to use steatite in their baths instead of soap, to soften the skin; and Humboldt states, that the Otomacs,

a savage tribe on the banks of the Orinoco, resort to a species of it for their food in the failure of other aliment.

The alkali, soda, distinguishes a number of minerals, none of which fall within our province to notice.

Both alkalies appear in *obsidian*, a glassy volcanic product, often called volcanic glass; in *pumice*, a familiar article of commerce, likewise volcanic; in *tourmaline*, which presents brilliant crystals of several colours, but usually black; and in *lapis lazuli*, azure-stone, celebrated for the rich blue extracted from it, termed ultramarine, so highly valued by painters. Its chief localities are Siberia, China, Persia, Bokhara, and the banks of the Indus.

Acids.

Thirteen acids are known to mineralogists, three of which, the sulphuric, boracic, and arsenious, are met with in an isolated or uncombined condition, but the instances are rare, and the products wholly unimportant.

Acidiferous Earthy Minerals.

In the composition of minerals of this class, the various acids are found in combination with different earths, forming some of the most abundant, useful, and beautiful substances in the great scheme of inanimate nature. It will only be necessary to notice the combinations of this kind of the carbonic, sulphuric, and fluoric acids.

The valuable earth, lime, employed to form mortar, and scattered by the agriculturist over his fields to promote the fertility of soils, has been used for the former purpose from remote antiquity, as its presence among the ruined masses of Babylon denotes. The vast abundance in which it has been furnished will be appreciated from the mere mention of limestone, a variety of which forms immense tracts of elevated country, and is hence called mountain-limestone. Other varieties yield the ordinary building-stone of various districts, quarried from massive beds beneath the soil; while the chalk exposed in cliffs along our south coast, and spreading in wavy downs over a wide area inland, is integrally the same substance. But natural arrangements are not more bountiful than wise; and hence, while conferring a benefit upon man, it is made in this instance the reward of industry, lime being never supplied ready made to his hands, or existing in a pure state in nature. In order to be obtained in that condition, it has to undergo the process of burning in a kiln for some days, when heat expels the ingredients combined with it, and leaves what is properly lime fit for the purposes of cement and manure. In nature, the most common form under which it occurs is in combination with carbonic acid, forming carbonate of lime.

The varieties under which carbonate of lime appears are too numerous to admit of being particularized in these pages. The purest is *calcareous spar*, which is found crystallized in

nearly all the rocks of every country, the crystals presenting great diversity of shape and colour. Particular localities, as Derbyshire, are famed for fine specimens, but Iceland furnishes the most remarkable, colourless and transparent. *Stalactites*, pendent from the roofs of caverns, and *Stalagmites*, rising from their floors, are limestone formations now in process from water saturated with lime.*

Under the generic name of limestone a great variety of kindred products are grouped. A granular crystalline species yields *statuary marble*, used by the sculptor, which the French denominate *Chaux carbonatée saccharoïde*, from its having the pure white colour and transparency of loaf-sugar. The ancient artists employed this material for their finest works, and obtained it from the islands of Paros in the Archipelago, hence called Parian marble. An inferior kind, marked with bluish-grey veins, they termed Pentelicon marble, from its site, the mountain of Pentelicus, on the north-east of Athens. The Carrara quarries, on the east coast of the gulf of Genoa, where the face of a mountain has been opened to the height of eight hundred feet, chiefly supply the modern statuary.

The ordinary limestones are more impure, but contribute largely to our social comfort. *Mountain limestone*, so called from forming elevated ranges, is of a blue-grey tinge, often susceptible of a high polish, and is worked into marble slabs for chimney-pieces, pilastres, and

* See Monthly Volume, "Caves of the Earth," p. 34.

ornaments. The colour sometimes passes into deep black, due to the oxide of iron, fitting it for funereal monuments. *Oolitic limestone*, or roe-stone, named from the resemblance of its rounded grains to the roe of a fish, is extensively used as a building material. Portland stone, obtained from quarries in the Isle of Portland on the Dorset coast, is a variety, of which St. Paul's Cathedral, Goldsmiths' Hall, the Reform Club House, and other metropolitan edifices, are built. Bath stone is another, forming the material of the abbey church and great part of the city, and is quarried in the neighbourhood. Caen stone is similar, which was largely brought from Normandy, and employed in English edifices of an early date, as in Canterbury Cathedral. The stone used in lithography is a related product, distinguished by closeness of grain, deep cream colour, and capability of being reduced to a perfectly smooth surface. *Chalk* is a limestone, less compact, but nearly pure, readily converted by the action of heat into quicklime, or the pure earth, which, besides the services already referred to, forms the substance called whiting, used as a marking material, likewise in whitewashing, polishing glass and metals. England and France contain chalk in a greater proportion than probably any other countries of the globe.

Lime, in connexion with sulphuric acid and water, forms *gypsum*, which occurs in very extensive beds, and is applied to many useful

purposes. Having been heated and ground, plaster of Paris is prepared from it, a well-known cement, used in facing walls, taking casts of statues, and named from the material being quarried in the hills of Montmartre, near the French capital. Fine varieties of gypsum, snow-white and veined, take the name of alabaster, from Alabastron, a village in Egypt, one of the localities which chiefly supplied it to the ancients. Derbyshire affords it in large masses, which are worked for columns and ornamental objects.

Lime, again, in combination with fluoric acid, forms *fluor spar*. This very beautiful mineral is generally found in veins, abundantly in Derbyshire, Cornwall, and Cumberland, where it is known as the "Blue John" of the miners, from its rich blue tints, passing into green, purple, and other colours, including the perfectly white. .

Carbonic acid and the earth magnesia are the main ingredients of the peculiar substance called by the Germans "*Meerschaum*," literally sea-foam, obtained in various parts of the Levant, where it is used as fullers' earth is with us. Combined with sulphuric acid, magnesia appears in the medicine *Epsom salts*, which occurs in several mineral waters, as in springs at Epsom, and in efflorescences on the surfaces of certain rocks ; but it is artificially prepared to meet the extensive demand for it.

Both the earths referred to, lime and magnesia, with carbonic acid, appear in *magnesian*

limestone, a formation running in a range of low hills along the borders of Nottinghamshire and Derbyshire, into Yorkshire. Varieties of this material, admirably adapted for architectural purposes, appear in some celebrated structures, York Minster, Westminster Hall, and the new Houses of Parliament. The particular kind employed in the last-named edifice is from quarries at Bolsover, in Derbyshire; but was not much known till the qualities of all our building stones were tested by a commission, in order to select the best for the new legislative palace. It has nearly four times the cohesive power of Portland stone; and owing to the distinction obtained, it may not be out of place to give its chemical composition—51 per cent. of carbonate of lime, 40 per cent. of carbonate of magnesia, and more than $3\frac{1}{2}$ per cent. of silex.

Acidiferous Alkaline Minerals.

The substances which have for their chief components an acid and an alkali are embraced under this head, and are generally found impure in nature.

Nitre, or *saltpetre*, composed of nitric acid and potash, principally appears upon the surface of great plains in the form of a saline crust, India, Persia, Hungary, Egypt, and Spain, being the most abundant localities; but it is largely manufactured, owing to the natural supply failing to meet the extensive demand made for it in the arts, medicine, metallurgy, and the production of gunpowder. *Natron* consists of car-

bonic acid and soda, forming carbonate of soda. It is found appearing like heaps of snow on the plain of Debretzin, in Hungary, during the heat of summer; but it is obtained in larger quantities from lakes in Egypt, whose waters hold it in solution, and deposit it in their beds. These lakes are to the south-west of the Delta, full of water in winter, which the great heat of summer evaporates, leaving a thick crust at the bottom. Natron, called nitre by the ancients, was used as a soap. It enters now into its manufacture, being also employed in bleaching, dyeing, and other processes. Hence the remark of the prophet Jeremiah, "Though thou wash thee with nitre, and take thee much soap, yet thine iniquity is marked before me," ii. 22. In the book of Proverbs it is stated: "As he that taketh away a garment in cold weather, and as vinegar upon nitre, so is he that singeth songs to an heavy heart," xxv. 20. The simile alludes either to the disagreeable odour arising from natron when vinegar is poured upon it, or to its purifying power being destroyed.

Common salt, a compound of chlorine and soda, is furnished in vast abundance, like all the other substances which are not articles of luxury, or merely of convenience, but essential to the life of man and beast. The ocean holds it in solution; many lakes and springs contain it in a far larger proportion; and from their waters table salt is extensively prepared, by artificial means of evaporation in cold climates, or the heat of the sun in hot countries. But the

mineral occurs in the solid form in immense beds as rock-salt, exhibiting various shades of colour according to the impurities which generally mingle with it, often a dull red tint. Some of the chief European deposits, which have long been worked, and subterranean excavations formed of enormous extent, are at Nantwich and other places in Cheshire; the valley of Cardona, in the Pyrenees; Bex, in Switzerland; Hall, in the Tyrol; and Wieliczka, near Cracow, in Poland. The position of the mineral at these sites is very varying; in low ground in Cheshire; elevated at Bex some height above the lake of Geneva, which is itself more than a thousand feet above the sea; while in Savoy and the Andes, it reaches a height equal to that of the perpetual snow.

The rock salt of Cheshire was discovered in the year 1670, during an unsuccessful search for coal. It is found in several beds, of different thickness, which lie at the depth of from one hundred and fifty to four hundred and fifty feet below the surface. The mines are entered by shafts, and in some cases the subterranean excavation includes an area of several acres. Over this great space the roof is supported by huge pillars of salt, left in working out the mineral, which "add to the picturesque effect, in relieving the deep shadows, and giving the eye an object on which to rest. The intervening portions are loosened from the rock by blasting, and it may be readily understood that the effect of the explosions heard from time to

time, and re-echoing through the wide spaces, and from the distant walls of rock, give a grandeur and impressiveness to the scene not often surpassed. The great charm, indeed, on the occasion of a visit to these mines, even when they are illuminated by thousands of lights, is chiefly owing to the gloomy and cavernous appearance, the dim endless perspective, broken by the numerous pillars, and the lights, half disclosing and half concealing the deep recesses which are formed and terminated by these solid and monstrous projections."

Salt mines are far more agreeable to visit than coal and others, owing to noxious gases being more rare. The mine at Wieliczka is the most extensive example, the mineral occurring here, as in Cheshire, reddened with sediment from the overlying marls. Half a century ago, the total length of excavation amounted to eight miles, and must be now much more extended, the whole depth from the surface being nine hundred feet. Besides subterranean chambers for managers and men, and a stable for horses, there is a chapel, thirty feet in length by twenty-four in breadth, and eighteen in height, every part of it, the floor, the roof, with its supporting columns, the altar, the crucifix, and several statues, being cut out of the solid salt.

Ordinarily we use salt, merely considering it an article which renders food more agreeable to the palate; but it fulfils a more important office, and is in fact essential to the functions of

life. Nature craves it with intense desire if deprived of it for a season. Mungo Park, in the account of his travels in Africa, states: "I have suffered great inconvenience from the scarcity of this article; the long use of vegetable food creates so painful a longing for salt, that no words can sufficiently describe it." As a severe punishment, the old laws of Holland condemned a class of criminals to be fed on bread unmixed with salt, and the effect was horrible, for they are reported to have died, like Herod, self-devoured. All warm-blooded animals participate with man in needing this stimulant to the digestive organs; and in their wild state they instinctively make their way over immense tracts of country to the spots where it may be found. These places are hence called "salt-licks" in America, from the animals resorting to them to drink at the brine spring, or lick the earth impregnated with saline particles. The copious stores of this essential substance evidence the care of a gracious Providence, for any scarcity of it in a country arises more from intelligence being wanting among its inhabitants, than from a real local deficiency marking the arrangements of nature.

Acidiferous Alkalino-Earthy Minerals.

The constituent parts of these substances are an acid, an alkali, and an earth. But such compounds are rare, and have no intrinsic interest or economic value, with one exception,

the well-known *alum* of commerce, largely used in various arts, the manufacture of paper, leather, and processes of dyeing. The mineral takes its name from one of its bases, the earth alumine, and is often styled *rock alum*, from Rocca, the present Edessa, in Syria, one of its celebrated localities. It seldom occurs as a prepared product in nature, but its components are found at certain sites, and there alum-works are established, for the purpose of so arranging the materials, greatly disposed to unite, as to form the mineral. Thus the extensive range of lofty cliffs at Whitby, in Yorkshire, contain alumine, potash, and sulphuric acid, the ingredients of alum, and there it is extensively prepared.

In the course of this chapter, notice has been taken of the references made by the sacred writers to some of the products which have been named. It may close with the remark, that perhaps no natural substance is alluded to more frequently, or in such an interesting and important manner, as one of the articles just mentioned, the salt of the earth, owing to its properties being familiarly known, and its abundant occurrence in Palestine. It is found in masses around the southern shore of the Dead Sea, contiguous to which "the city of salt," Josh. xv. 62, so called in reference to its locality, appears to have been situated; and the "valley of salt," 1 Chron. xviii. 12, the scene of a victory over the Edomites in the time of David. As indispensable to the enjoyment of food, the

name became a denomination of sustenance generally, and of the money wages which procure it. Hence the phrase in the book of Ezra, iv. 14, "we have maintenance from the king's palace," is rendered in the margin, "we are salted with the salt of the palace," or are in the pay of the sovereign. These are common acceptations of the term at present throughout the east. As its superabundance in a district is incompatible with vegetable life, it frequently occurs as an image of sterility. Hence, of "the man that trusteth in man, and maketh flesh his arm, and whose heart departeth from the Lord," it is declared, to express his desolation, that his lot shall be cast "in a salt land and not inhabited," Jer. xvii. 6. As tending to perpetuate corruptible substances impregnated by it, contracts, intended to be permanent, were often ratified by the contracting parties eating salt, an agreement of that kind being termed "a covenant of salt," 2 Chron. xiii. 5. As contributing to flavour food, and adapt it to wholesome purposes, it is introduced as the emblem of the conversation befitting the Christian character, and beneficial to society: "Let your speech be alway with grace, seasoned with salt," Col. iv. 6. Lastly, our Lord, referring to its general utility in the economy of life, styled his disciples "the salt of the earth," Matt. v. 13, in allusion to that beneficial influence upon mankind which they were constituted and adapted to exert by their teachings and example. Let the modern professing Christian

remember that this is his own high vocation, and that just as he fails to fulfil it, he becomes as salt that has lost its savour, a worthless product, "thenceforth good for nothing, but to be cast out, and to be trodden under foot of men."

CHAPTER V.

METALLIFEROUS MINERALS.

Properties of metals—Gold—Silver—Iron—Copper—Lead—Tin—Mercury—Antimony—Manganese—Zinc—Platinum—Cobalt—Chromium—Bismuth—Arsenic.

METALS, which hourly appeal to our senses in the implements and utensils of civilized life, and exercise an influence the most important upon the comfort of human beings, are readily distinguishable from other mineral substances, when separated from foreign ingredients, by the exhibition of various properties in different degrees. They are not penetrable by light, even when reduced to plates of extreme thinness; they are not soluble in water; they admit of heat and electricity passing rapidly through them; their specific gravity or weight generally exceeds that of other bodies; and they possess that peculiar lustre termed metallic. There are other secondary qualities, which, though not common to all metals, belong to those which are of the most use in the business of common life, and contribute to fit them for the purposes

of man. These qualities, which vary in degree, are—*malleability*, or the capacity of being hammered into thin plates, and into various forms, without breakage, as in the case of most earthy minerals when similarly treated; *fusibility*, or the power of being rendered fluid by heat, at degrees of temperature attainable by artificial means; *ductility*, or the property of being drawn out into wire; and *tenacity*, or the capability of supporting heavy weights without separation of their component particles.

Including the metallic bases of the earths and alkalies, the number of metals hitherto discovered amounts to forty-two; but the metals commonly so called are twenty-nine, which, arranged according to their weight, are as follows:—Platinum, *gold*, tungsten, *mercury*, *lead*, palladium, *silver*, bismuth, uranium, vanadium, *copper*, cadmium, cobalt, arsenic, nickel, *iron*, molybdenum, *tin*, zinc, antimony, tellurium, manganese, titanium, chromium, columbium, rhodium, iridium, osmium, cerium. Of these, some are very rare, and at present of no practical service, however the advance of knowledge may elicit valuable properties. Attention, therefore, will be chiefly confined to those which appear conspicuously in arts and manufactures, and are denoted in the preceding list by italics. These principal metals are arranged in the annexed table according to their possession of the qualities mentioned at the head of the columns, beginning with those which develop them in the highest degree:—

Malleability.	Fusibility.	Ductility.	Tenacity.
Gold.	Mercury.	Gold.	Iron.
Silver.	Tin.	Silver.	Copper.
Copper.	Bismuth.	Platinum.	Platinum.
Tin.	Lead.	Iron.	Silver.
Platinum.	Zinc.	Copper.	Gold.
Lead.	Antimony.	Lead,	Zinc.
Zinc.	Silver.	Bismuth,	Tin.
Iron.	Copper.	Tin, Zinc,	Lead.
Bismuth and	Gold.	and	Bismuth and
Antimony	Iron.	Antimony,	Antimony
are brittle.	Platinum.	cannot be	are brittle.
		drawn into	
		wire.	

Thus, gold is the most malleable and ductile of all metals, iron the most tenacious and one of the least fusible, while mercury is fluid at the common temperature of our atmosphere, and requires a cold of 72° below the freezing point in order to solidify, an intensity of cold not known in our climate.

Some of the metals, as gold, silver, platinum, and copper, occur nearly pure in nature, or free from foreign substances, in which case they are said to be *native*. Occasionally, two are found in combination, as silver with antimony, or with lead, constituting what is termed a *native alloy*, or an *amalgam* when mercury is present. But the usual form is that of *ore*, which consists of the metal combined with oxygen, sulphur, or acids, and mixed up with various earths. When in combination with oxygen, the descriptive term of an *oxide* is applied to that state; when with sulphur, a

sulphuret; and when with an acid, the name of the particular acid defines the compound.

In considering the metals, it is convenient to begin with those of the precious or noble class, gold and silver, so called from their office of measuring the value of other commodities, though vastly inferior to many kindred products, iron, copper, tin, and lead, in positive utility to mankind.

Gold.

The noblest of the metals has been an object of regard from remote antiquity, owing to its beauty and value, exhibiting, when quite pure, the peculiarly rich colour denominated golden, the only metal of a yellow hue. It is almost always found in the native, or metallic state, but commonly in combination with some alloy, either with silver, which, when important, forms argentiferous gold; or with iron, constituting auriferous pyrites. It occurs in veins, irregularly traversing the hardest rocks, which are opened for the treasure by ordinary mining operations. In this position, the metal may be said to be *in situ*, or in its natural place, but the expense of extracting it is so enormous, and the yield so scanty, that but few successful undertakings of the kind are conducted. By far the largest quantity is drawn, at a comparatively trifling cost, and in nearly a pure state, from sands and gravel in the beds of shallow rivers, and from extensive alluvial grounds, accumulated in valleys at the foot of high mountains. In this condition, the metal, with

the soil accompanying it, is not in its natural place, but a travelled product, auriferous rocks having been broken up by grand operations of nature, or slowly wasted by aqueous and other causes of disintegration, rains, streams, and torrents, officiating in the transport of the debris. By these means, a considerable supply has been placed within the reach of man, which never could have been extracted by engineering skill from the parent site, except at an immense loss; and the soil has only to be turned over, washed, and sifted, in order to collect the metallic particles. Incidents of the kind adverted to are of known occurrence. In the course of the last century, the lightning struck the projecting point of a great quartz vein, in one of the highest mountains of Paraguay, detached a vast mass of rock, and shivered the mountain-side into fragments, when a local supply of gold, perfectly inaccessible where it originally lay, or only to be obtained from it at a loss, was cheaply gathered from the disrupted material.

Native gold is found in scales, threads, grains, or rolled masses, which, when of a certain size, take the name of *pepitas*, and have occasionally been met with of magnificent dimensions. One of these, obtained from the fertile and picturesque tract of the south Ural mountains, in 1826, during the reign of Alexander, weighed upwards of twenty-two pounds avoirdupois. Of this there is a plaster model in the Museum of Natural History, in Paris. But, in 1821, a mass was found in the United States, in the

county of Cabarras, eight or nine inches long by four or five broad, and about an inch thick, which weighed twenty-eight pounds. A larger example was discovered in the alluvium of the island of Haiti, in 1502, which weighed upwards of thirty-two pounds. California has yielded specimens of very considerable magnitude, one of which, picked up in a dry ravine, near the Stanislaus river, in 1848, weighed a little over twenty-five pounds, but contained a large admixture of quartz. But far exceeding any of these, is a mass discovered November 7th, 1842, on the Asiatic side of the southern portion of the Urals, under somewhat singular circumstances. In this district, the mines of Alexandrofsky and Nicolaefsky, situated in the auriferous deposits of the river Miass, seeming exhausted, new explorations were made in the neighbourhood, and especially along the little river Targana. Great success attended the search for gold in that marshy plain, and the surface had been completely turned over, except that part of it occupied by the building in which the washing operations were carried on. In 1842, it was resolved to take down the workshops, whereupon sands were met with of immense richness, and under the very corner of a building a monster lump was found, weighing two *poods*, seven *Russian pounds*, and ninety-two *zolotnies*, equal to about ninety-six and a half pounds troy. It lay upon a stratum of diorite, at the depth of ten feet. The mass, now in the collection of the *Corps des Mines*,

at Petersburg, has an undulated surface, is somewhat porous, free from all trace of matrix, and its value may be estimated at about £4,000.

Gold is one of the metals which has been the longest known. It is first historically noticed in connexion with one of the rivers of Eden: "The name of the first is Pison; that is it which compasseth the whole land of Havilah, where there is gold; and the gold of that land is good." It was wrought into ornaments in very early times; for Abraham's steward, Eliezer, presented to Rebekah "a golden earring of half a shekel weight, and two bracelets for her hands of ten shekels' weight of gold." Joseph, likewise, received from Pharaoh a chain of gold, to be worn about the neck. In the construction of the tabernacle, and subsequently of the temple, the precious metal was largely used for adornments and implements. The gold districts recorded in the Old Testament are Ophir, Sheba, Uphaz, and Parvaim, localities which have given rise to various conjectures respecting their site, but which cannot now be identified. It is certain that all the powerful nations of antiquity, Egyptians, Hebrews, Assyrians, Babylonians, Medes, and Persians, had command of considerable supplies of gold; and if in the regions which lay within the sphere of their knowledge it does not now occur naturally as an available product, the reason is, that in these long-known districts the supply has been exhausted.

Though the gold-producing regions of importance at present are few, consisting chiefly of Hungary and Transylvania, the Ural and Altai mountains, the Andean countries, Brazil, Mexico, and California, the metal is very widely disseminated, and probably yields only to iron in its range; but the quantities are too small to repay the expense of collecting. It has been met with in four or five spots of our own country; and it is not unlikely that in very early times, the soils and gravels in these situations were somewhat prolific, supplying the Druids with the material for their ornaments, the tracts being mainly exhausted by them. Cornwall, North and South Wales, the borders of Lanarkshire and Dumfries, parts of Perthshire, and the county of Wicklow, in Ireland, are the sites in question.

On the southern borders of Lanarkshire, not far distant from the present Leadhills, during the reign of James v. three hundred labourers were employed in searching for the glittering product, at fourpence per day—no insignificant sum at that time—but the wages were speedily reduced to twopence, the article becoming more scarce, and the works were soon abandoned as unprofitable. The gold first appeared in the sands of the Elvan, a rivulet which joins the Clyde near its source; and a place long bore the name of Gold-scour, where the soil was washed. A specimen from another site, the Breadalbane estate, near Glen Coich, in Perthshire, which weighs almost eight sovereigns, is

now in one of the mineralogical cabinets of Edinburgh. Towards the close of the last century, Wicklow became famous for its gold, principally obtained from the Ballinavalley stream, a tributary to the celebrated "Meeting of the Waters," in that county. The first discovery is traditionally attributed to a schoolmaster, accustomed to haunt the banks of the streams, who grew gradually rich. The secret of his wealth transpired in the autumn of 1796, when a man crossing a brook found a piece in its bed weighing about half an ounce. The news was rapidly spread far and wide. Young and old of both sexes abandoned every other pursuit, crowded to the spot, and examined every river and rivulet for miles around it. At length the place was occupied by the troops of the government, and regular works commenced, which succeeded for a time, became less profitable, and were relinquished. But while the country was in the hands of the peasantry—about two months—it is believed that two thousand five hundred ounces of gold were collected, and disposed of for about £10,000.

Gold is so extremely malleable that a single grain, in the form of gold leaf, may be made to cover a surface of fifty-six square inches. In this state the leaf will be $\frac{1}{282000}$th part of an inch thick, and will float like a feather in the air. It is also so ductile that a grain may be drawn out into five hundred feet of wire. Though comparatively a soft metal when unalloyed, it requires a heat equal to 2,016° of

Fahrenheit to be fused, and may be kept in the hottest furnace for weeks without loss of substance, or undergoing any change, except remaining in a melted state; nor does exposure to moisture and the atmosphere produce any effect upon it. Gold is applied to many important purposes. Besides being employed for coin, to which reference will shortly be made, it forms the material of many articles of luxury possessed by the wealthy; and owing to its malleability, gilding with the costly metal is one of the cheapest modes of ornamenting homely objects, a use to which it is extensively devoted.

Silver.

This metal, distinguished by its brilliant white colour when pure, and capability of receiving a high polish, is largely found in the native or metallic state, not in alluvial soils, as in the case of gold, but imbedded in various rocks, where it occurs in veins, assuming arborescent and thread-like forms, and occasionally appearing in large insulated masses. One of these, taken from the mine at Hemmels-fürst, in Saxony, in 1750, weighed 140 pounds; another specimen, now in the royal collection at Copenhagen, obtained in the seventeenth century from the mines of Kongsberg, in Norway, weighs upwards of 560 pounds; two more examples, severally 238 and 436 pounds, have very recently been reported from the king's mine in the same locality; but the largest

masses have been discovered in the mines of Peru, one of which weighed 800 pounds. Besides being found in a native condition, silver forms, in combination with other substances, a variety of ores, the chief of which are *sulphuret of silver*, of a dark lead colour, consisting of the metal and sulphur; *red silver*, varyingly of a light crimson and a deep red, the most beautiful of the ores, containing antimony in addition to the ingredients named; *muriate of silver*, generally brown, composed of the metal, muriatic acid, and a small proportion of iron; and *antimonial silver*, of a white colour, a compound of the two metals. In addition to the proper ores of silver, a considerable quantity is found in the ores of other metals, especially those of lead, in which, though silver occupies a very subordinate place, its great value renders its extraction remunerative.

An important supply of silver is obtained from some of the European and Asiatic countries, but the great stores are in the western world, especially in Bolivia, Peru, and Mexico, which have yielded an enormous quantity since the period of their discovery.

In Bolivia, the mines of Potosi—a name which has become proverbial for wealth—have probably furnished more silver than any other part of the globe. They occupy a conical mountain of clay slate, capped with porphyry, called the Cerro de Potosi, which attains the height of 16,000 feet above the sea, but rises from a very elevated country, the great square

of the city of Potosi being at the height of 13,314 feet. Some of the sources of the river Plata (*silver*) are not far distant, a circumstance which originated the name. The riches of the region are said to have been discovered by an Indian, who, while engaged in chasing some animals, laid hold of a shrub to assist his ascent. It yielded to his weight, and some metallic particles being found attached to its roots, disclosed to him a silver vein, since called *la rica*, "the rich." Upon imparting the secret to his master, a mine was opened, and formally registered, April 21, 1545. The abundance of the ore speedily drew a concourse of adventurers to the elevated spot, where a stranger, on his first arrival, finds respiration difficult; the mountain was perforated in every direction; and Potosi, in the height of its prosperity, could boast of 130,000 inhabitants, with a stately cathedral, splendid churches, and edifices devoted to the produce of the mines. The city is now but the shadow of what it was at the commencement of the present century, owing to the political disturbances that have intervened, and the locality having been in a great degree exhausted of its wealth. From the opening of the mines to the separation of the country from the Spanish crown, a period of somewhat more than two centuries and a half, the silver which has paid the royal duty has been valued at upwards of £230,000,000.

At a similar altitude, on the Andes of Peru, are the mines of Pasco, which are still prolific,

after being worked without intermission for upwards of two centuries. There are here two very remarkable veins. One of them, the Veta de Colquirirca, runs nearly in a straight line from north to south, and has been traced to the length of almost two miles, being four hundred and twelve feet in breadth; the other vein is the Veta de Pariarirca, which takes a direction opposite to the former, and has a known extent of about one mile and a quarter in length, by three hundred and eighty feet in breadth. The two veins are supposed to intersect each other under the market-place of the city, and both have smaller veins branching off from them in various directions, forming a net-work of silver beneath the surface of the earth. In twenty years preceding 1803, no less than 3,086,420 pounds troy of silver were obtained from these mines, equal to about £7,000,000 in value. The population of the place presents a motley assemblage of human beings, "such as one would scarcely expect to find in a city situated at fourteen thousand feet above the sea, and encircled by wild mountains. The Old and the New World seem there to have joined hands, and there is scarcely any nation of Europe or America that has not its representative in Cerro de Pasco. The Swede and the Sicilian, the Canadian and the Argentinian, are all united here at one point, and for one object. The inhabitants of this city may be ranked in two divisions, namely, traders and miners, taking both terms in their most comprehensive sense.

The mercantile population consists chiefly of Europeans or white Creoles, particularly those who are owners of large magazines. The keepers of coffee-houses are here, as in Lima, chiefly Italians from Genoa." Among the miners, the proprietors are mostly the descendants of old Spanish families, and the labourers are Indians.

Mexico still maintains its ancient renown for silver, and is at present its most abundant source, though social troubles have powerfully checked productive industry in the country. The mines are near the summit, or on the western flank of the great table-land, the highest being at the elevation of nearly ten thousand feet above the sea. At the richest site now worked, that of Veta Grande, four miles north of Zacatecas, there is one principal vein, from eight to thirty feet thick, separating in places into three or four branches. This mine yielded to its proprietors a net profit of £176,000 and £196,000 in the years 1831 and 1832.

Among the metallic products of the United Kingdom silver occupies a very subordinate place. Yet in the last century a vein was wrought in the parish of Alva, in Stirlingshire, with considerable advantage, though soon exhausted. In Cornwall, Devonshire, Derbyshire, and other places, it usually accompanies galena, a rich sulphuret of lead, and it is often worth while to extract it by exposing the argentiferous lead to a high temperature. The silver rarely amounts to a hundred ounces per ton of lead, and in some districts the average proportion is

not more than twelve ounces, but it may frequently be separated with profit, when it exists only to the extent of eight ounces per ton.

Silver yields only to gold in malleability, and may be beaten out into leaves of $\frac{1}{160000}$th part of an inch in thickness. It excels it in tenacity; for while gold wire, the tenth of an inch in diameter, will only bear the weight of a hundred and ninety-one pounds, silver wire of the same size will support a weight of two hundred and fifty pounds. It is extensively used in the arts of life, as for plating other metals, giving to inferior materials its own brilliant appearance, and for the manufacture of luxurious or ornamental articles. Mankind were acquainted with the metal at an early date, and employed it for the latter purpose—Joseph's "silver cup," mentioned by his steward as that "in which my lord drinketh," being the first instance recorded in history. An oxide of silver is used to give a yellow colour to porcelain. Nitrates and iodides contribute to the new process of daguerreotype. The nitrate is also the well-known lunar caustic of surgery, employed for cauterizing wounds; dissolved in gum-water, it forms an indelible marking ink; and mixed with alcohol, a fulminating powder is produced.

The use of silver seems to have long antedated that of gold, as a medium of exchange for the articles of life, the most important application of the precious metals. The earliest record of gold being employed as money refers to the time of David, who purchased the thresh-

ing-floor of Ornan for six hundred shekels of gold by weight. But in the patriarchal age, we read that Abraham received from Abimelech a thousand pieces of silver, and purchased a burying-place of the children of Heth for four hundred shekels of silver, "current money with the merchant." In these cases, the money passed as bullion from the buyer to the seller, not as coin, and was weighed instead of being counted out.

To form durable coin, resisting the wear and tear of circulation, both metals are alloyed with some harder material. The standard gold of the realm contains an alloy of perfectly pure copper, in the proportion of one part of copper to eleven of gold. This addition renders the gold harder, without interfering with its capacity to receive the impression of the dies in the process of coining, and at the same time deepens the natural colour. Standard silver consists of about one part of copper to twelve and one-third of silver. The monetary application of the precious metals is a great convenience to society, vastly simplifying its business transactions. These representatives of value lie within narrow compass, and are readily told out, whereas the purchase of commodities by exchange of goods would be often impracticable, and always tedious—a cumbrous clog in the economy of life. But to use money as not abusing it, is a lesson which the depravity of man renders him slow to learn. Its acquisition is too often made the prime purpose of existence,

and its selfish hoarding, or expenditure in the gratification of lawless passions, is largely exemplified. All this is deeply criminal, highly offensive in the sight of God, and visited with the severest reprehension in his word; while earthly riches thus regarded minister no present good to their possessor, and become a pathway to poverty indescribable in the world to come. "The silver is mine, and the gold is mine, saith the Lord of hosts." They are only legitimately sought in subordination to the higher blessings proposed by his grace and mercy; and are alone rightly used when, after supplying the needful wants of the individual, the superfluity is disposed of in meeting the temporal and spiritual need of our fellow-creatures.

Iron.

Of all the metals, iron is the most truly useful to man, the most widely disseminated, and one of the most abundant. It was known in remote antiquity, even to the population of the antediluvian world, for Tubal Cain is mentioned as "an instructor of every artificer in brass and iron." Owing to its very rare occurrence in the metallic state in nature, and the immense difficulty of producing it in a condition adapted for use, it has not unreasonably been supposed that an inspiration, emanating from Supreme Wisdom, first suggested the admirable art of its fabrication, thus rendering the common gift of its ores available. Repeated references are made to the product in the writings of Moses,

yet on account of the circumstance just named it was only very sparingly employed by the ancient nations, and has usually been one of the last metals which men have pressed into their service. Only a few insignificant articles of iron have been found in the tombs of the Egyptians, whose mighty monuments were hewn with bronze tools, while their weapons and domestic utensils were of the same materials, as appears from the green colour given to them in their paintings. According to Hesiod,

> "Men wrought in brass when iron did not exist."

In the account of the erection of the tabernacle in the wilderness, no notice occurs of iron. The swords of Homer's heroes were of copper, hardened by tin; and it shows the rarity of iron, and the high value consequently attached to it, that Achilles proposed a ball of the metal as a prize when he celebrated games in honour of Patroclus :—

> "Then hurl'd the hero, thundering on the ground,
> A mass of iron, an enormous round,
> Whose weight and size the circling Greeks admire,
> Rude from the furnace, and but shaped by fire."

In the New World, likewise, the age of brass preceded that of iron. Though the ore lay around the Mexicans and Peruvians in great abundance, they could not turn it to account, and, like the Egyptians, found a substitute for it in an alloy of tin and copper, of which their tools and weapons were made.

Native iron of terrestrial origin is a very

rare production, only a few small specimens having been found; but the nearly pure metal occurs in those mysterious masses, observed in various countries, lying upon the surface, or partly imbedded in the soil, so alike in composition, and yet so different from any other product of the earth, as to lead to the supposition that they belong to the class of meteoric bodies, or aerolites, which fall occasionally from the atmosphere. Hence the term *meteoric iron* is applied to these objects; and one instance is on record of the actual descent being witnessed, near Agram, in Croatia, in the year 1751. Pallas observed a mass of this description in Siberia, on the top of a mountain near the river Yenesei, far away from any allied object, which weighed 1,512 pounds; and another, now in the Yale College cabinet, in the United States, weighs 1,635 pounds. But still more remarkable masses exist in South America, amounting to the estimated weight of fifteen tons. A portion of one of these gigantic bodies, from the plains of Otumba, in the district of Buenos Ayres, is now in the British Museum, and weighs 1,400 pounds. The origin of these masses, along with that of the meteoric stones, whose fall has been repeatedly witnessed, is quite unknown. Meteoric iron is perfectly malleable, and may be readily worked into cutting instruments, and put to the same uses as the manufactured metal.

The ores of iron are numerous, but many are mere curiosities, and only the most important need be mentioned. *Magnetic iron ore*

is a black oxide, rich in the metal, which is of the finest quality, exhibiting the property of magnetism. It occurs in vast masses in Sweden, particularly at Dannemora, to the north of Upsal, where celebrated mines have been wrought upwards of three centuries; and at Taberg, a mountain near the great lake Wetter, which has annually yielded immense quantities through the same length of time. It is plentiful in the Ural mountains, the remarkable hill of Blagodat, a name signifying "benefit," or "blessing," being composed of it. This hill, to the north of Ekaterinburg, rises out of a plain, and presents two rugged naked peaks. A wooden bridge spans the cleft between them, and appears to hang in the air. The lower peak is ascended by a flight of narrow steps, cut in the rock, whence, passing over the bridge, the path conducts to a neat stone chapel on the other eminence. It is related, that one of the Voguls, the aborigines of the district, communicated the existence of this iron mountain to the Russians; the result was an immediate irruption of mining adventurers, whose presence proved so unwelcome to the old inhabitants that they burned their communicative countrymen alive on the Blagodat, and erected the chapel on the spot, repenting of their cruelty. Very powerful magnets, capable of raising a hundred times their weight, were at one time procured from the mines at this spot, but few now are met with exerting more than a sustaining power of forty times their weight.

Another important species, *specular iron ore*, so called from its brilliancy, forms extensive beds, and even entire mountains, yielding a rich per centage of metal. Its most celebrated locality is the island of Elba, where, though the mines have been worked more than two thousand years, the supply is apparently inexhaustible. *Red iron ore*, also called *hematite*, in allusion to the blood-red colour, though there are other shades, is plentiful in a vast number of localities. It traverses, in a thick vein, the mountain limestone near Ulverstone, in north Lancashire, and affords iron of very superior quality. But in Great Britain the great supply of the metal, equal to nineteen-twentieths of the whole, is drawn from *clay iron-stone*, of a grey, brown, or blueish-grey colour, scarcely distinguishable from an ordinary stone, except on account of its greater weight.

Clay iron-stone occurs chiefly in the coal formation. It is found in the form of rounded boulders, in thin beds, several of which usually overlie one another in the same locality, separated by sandstone strata, indurated clays, or layers of coal. The iron-stone mines are generally much more wet and cold than those of coal, and are proportionably more productive of those diseases which result from such circumstances. In consequence of the thinness of the beds, and the clearing away of as little space as possible on account of the expense, horses cannot be employed in conveying the ore from the workings to the foot of the shaft, a service

therefore performed by manual labour, while the same cause renders it more difficult to ventilate the mines properly. Except in these points our iron-stone and coal mines agree in their main features, and both products are often raised to the surface through the same shaft. The ore is comparatively poor, containing, on the average, not more than thirty-five per cent. of iron; but its abundance, with the juxtaposition of coal and limestone for smelting it, are amply compensating advantages. Oxygen gas, carbonic acid, small quantities of earths, and a few other ingredients, appear in combination with the metal in the ore. The process of smelting, by which they are separated from it, consists in subjecting the iron-stone to very powerful heat, and bringing it in contact with other substances, which, having a stronger attraction for oxygen and carbonic acid, destroy the combination, and set the iron free.

The countries which produce the metal upon a great scale are, Great Britain, France, Belgium, Spain, Saxony, Austria, Sweden, Russia, and the United States, in all which the supply appears likely to last for ages. The chief home sites of production are Staffordshire, Shropshire, South Wales, Derbyshire, Yorkshire, Lancashire, in England; Lanarkshire and Stirlingshire, in Scotland. The total annual amount of British iron made is now probably not far short of two millions of tons. In the year 1839, it was estimated at 1,350,000 tons. In order to obtain this quantity, it was calculated

that upwards of 4,000,000 tons of ore, 1,500,000 tons of limestone, and 7,000,000 tons of coal, were extracted from the bowels of the earth; while, in addition to steam power, the labour of 100,000 human beings was employed in the process.

The existence of the iron manufacture in any locality being determined by the readiness with which the iron-stone, as well as the limestone and fuel necessary for its fusion, can be procured, its site is liable to change whenever any one of the three raw materials is either exhausted, or can be procured at less cost elsewhere. Thus, from this cause it has been transferred, in our own country, from the undulating sylvan glades of south-eastern England, north-westward to the rugged region of the coal fields. Iron ore of rich quality is plentiful in the Weald, or woodland of Kent, Surrey, and Sussex. This district, now abandoned to hops, pastoral and agricultural occupations, once had roaring furnaces, sending up tall columns of smoke, prominent in the landscape; while, day and night, the clashing noise of iron hammers beating upon iron was heard far and wide. Cambden says, "Sussex is full of iron mines everywhere, for the casting of which there are furnaces up and down the country, and abundance of wood is yearly spent; many streams of water are drawn into one channel, and a great deal of meadow ground is turned into pools, for the driving of mills by the flashes, which, beating with hammers upon the iron,

fill the neighbourhood, night and day, with their noise. The iron here wrought yields no small profit to the proprietors of the mines, who cast cannon and other articles in it."

One of the earliest notices of the manufacture in Sussex dates in the year 1290, and relates a payment made for the iron-work of the monument of Henry III. in Westminster Abbey, to master Henry, of Lewes. In the time of Edward II., the sheriff of Surrey and Sussex had to provide within his district, for the expedition against Scotland, three thousand horse-shoes and twenty-nine thousand nails, which, with the expense of carriage and delivery in London, cost £14. 13*s*. 10*d*. The first iron cannons cast in England were manufactured at Buxted, in 1543, during the reign of Henry VIII., the production of heavy ordnance giving a great impulse to the trade. Richard Woodman, a native of this place, and a considerable iron master, was one of the Marian martyrs, burned at Lewes in 1557. In his examination before the bishop of Winchester, he affectingly states, "Let me go home, I pray you, to my wife and children, to see them kept, and other poore folke that I would set aworke, by the helpe of God. I have set aworke a hundred persons, ere this, all the yeare together." In consequence of the great extent of the manufacture, and the enormous destruction of timber, a scarcity of wood for ship-building was apprehended, so that the legislature interfered in the time of Elizabeth, prohibiting new iron-works, except

within certain limits, and placing restrictions upon the consumption of the forests. But, in the seventeenth century, there were one hundred and forty furnaces in Sussex alone. Their multiplication was effectually checked, and the existing works abandoned, when the cheaper method of smelting with pit-coal was discovered. Gradually the noise of the hammer ceased—the smoke ascended in fewer columns—furnace after furnace died out—pastoral life regained its ancient ascendency—and the manufacture vanished from the Weald. Yet monuments of it remain in some fine sheets of water, though many have by draining been converted into hop gardens or osier beds; and in St. Paul's Churchyard, the passenger may see a specimen of Sussex-made iron, in the balustrades around the cathedral.

Pure iron holds the first place among the metals in point of tenacity, its strength being nearly four times that of gold, and almost twice that of copper, the next to it in the possession of this property. A copper wire, one-tenth of an inch in diameter, will support 392 pounds' weight; but one of iron, of the same diameter, will sustain 705 pounds. Next to platinum, it is the most infusible of metals, requiring a heat equal to 3,480° of Fahrenheit to bring it into a melted state; but this difficult fusibility is more than compensated by the power of welding being possessed in high perfection, or of being made to unite by hammering when at a white heat. Cast iron, or

the pig iron of the workmen, is the raw, impure material, first obtained from the smelted ore, the state in which the metal is commonly sold. It is neither ductile nor malleable, but very brittle, and incapable of being welded, as it melts with facility at a red heat. Malleable, or bar-iron, is produced from it by repeated processes of melting, during which its impurities are removed. The more completely the iron is set free from them, the more infusible it becomes, till, at the same temperature, it remains solid, and acquires the name of malleable iron, from the property of altering its form under the hammer. Steel is the metal at a particular stage in the transition from cast to malleable iron, rendered harder, more elastic, and brittle, by immersion in cold water while red hot. The various products we have named enter into the construction of an endless variety of important objects—the hardwares of domestic economy—the implements of agricultural industry—roads, and the mighty locomotives that traverse them—steamers ploughing the ocean—buildings, machinery, and the tools by which most handicrafts are pursued—while iron officiates as a most important medicine.

Copper.

In the list of metallic bodies distinguished for extensive utility, copper ranks next to iron, and officiated in its place among the ancient nations, who, if not ignorant of the art of procuring the other metal, were unable to do it with

facility. It is frequently found in a state of purity, and some large masses have been observed, but they are not of common occurrence. The commercial supply is obtained from ores, extracted from veins or beds, the varieties being very numerous, and in several instances very beautiful. *Malachite*, a highly valued ornamental stone, is a green carbonate of copper, noble specimens of which have been yielded by the Uralian mines. A monster block, in the museum at Petersburg, weighs more than forty tons, and is valued at a sum exceeding twenty thousand pounds. The most common and the best ores are those in which the metal is combined with sulphur and iron, in nearly equal proportions, forming copper pyrites, other metals sometimes occurring, but holding a subordinate place. This is the chief ore in Cornwall, the most productive copper district of the globe. It supplies considerably more of the metal than what is required for home consumption, and hence shipments of it are made to foreign countries. For want of fuel, the ores are taken to South Wales to be smelted, the vessels bringing back coal for the use of the steam-engines at the mines.

There are upwards of a hundred copper mines in Cornwall, principally situated between the town of Truro and the Land's End, the most important lying around Redruth. The following graphic description has been given of this district, as seen from the summit of Cairn Marth, a granitic hill, rising from seven to eight

hundred feet, in the neighbourhood of the last-named town: "Over a surface, neither mountainous nor flat, but diversified from sea to sea by a constant series of low undulating hills and vales, the farmer and the miner seem to be occupying the country in something like the confusion of warfare. The situations of the consolidated mines, the united mines, the Poldice mine, etc., are marked out by spots a mile in length by half a mile in breadth, covered with what are termed *the deads* of the mine—that is, slaty poisonous rubbish, thrown up in rugged heaps, which, at a distance, give the place the appearance of an encampment of soldiers' tents. This lifeless mass follows the course of the main lode, and from it, in different directions, minor branches of the same barren rubbish diverge through the fertile country, like the streams of lava from a volcano. The miner being obliged to have a shaft for air at every hundred yards, and the stannary laws allowing him freely to pursue his game, his hidden path is commonly to be traced by a series of heaps of *deads*, which rise up among the green fields, and among the grazing cattle, like the workings of a mole. Steam-engines, and *whims*, (large capstans worked by two or four horses,) are scattered about; and in the neighbourhood of the old, as well as of the new workings, are sprinkled, one by one, a number of small whitewashed miners' cottages, which, being neither on a road, nor near a road, wear, to the eye of the stranger, the appearance of

having been dropped down *à-propos* to nothing. Such, or not very dissimilar, is in most cases the superficial view of a country, the chief wealth of which is subterraneous.

"Early in the morning the scene becomes animated. From the scattered cottages, as far as the eye can reach, men, women, and children of all ages, begin to creep out; and it is curious to observe them all converging like bees towards the small hole at which they are to enter their mine. On their arrival, the women and children, whose duty it is to dress or clean the ore, repair to the rough sheds under which they work; while the men, having stripped and put on their *underground* clothes, (which are coarse flannel dresses,) one after another descend the several shafts of the mine, by perpendicular ladders, to their respective levels or galleries—one of which is nine hundred and ninety feet below the level of the ocean. As soon as they have all disappeared, a most remarkable stillness prevails—scarcely a human being is to be seen. The tall chimneys of the steam-engines emit no smoke; and nothing is in motion but the great *bobs*, or levers of these gigantic machines, which, slowly rising and falling, exert their power, either to lift the water or produce from the mine, or to stamp the ores; and in the tranquillity of such a scene, it is curious to call to mind the busy occupations of the hidden thousands who are at work, to contrast the natural verdure of the country with the dead product of the mines, and to observe a few cattle ruminat-

ing on the surface of green sunny fields, while man is buried and toiling beneath them in darkness and seclusion."

The metal is obtained in other parts of the United Kingdom, but not extensively. It was at the now exhausted copper mine of Ecton, in Staffordshire, that gunpowder for blasting was first used in England, introduced from the continent by some German miners, brought over by prince Rupert, about the year 1632. Some idea may be formed of the extensive scale on which this dangerous operation is carried on from the statement, that in Cornwall only the annual consumption of powder is estimated at four hundred tons' weight. Copper is largely produced in Chili, Cuba, Germany, Sweden, the Urals and the Altai; to a far less extent in France, Spain, Hungary, and Norway; South Australia and Lake Superior being newly discovered districts of the richest promise.

Copper derives its name from the island of Cyprus, where it was obtained by the Greeks. It was known in the earliest ages of society, and could hardly fail to attract the attention of mankind, as in unoccupied countries, even in the present day, it is often met with by explorers exposed at the surface. The Hebrew, *nechosheth*, translated "brass," obviously means copper, as in the passage, alluding to the mountains of Judæa, "out of whose hills thou mayest dig brass," a substance which does not exist in nature, but is always made artificially, copper entering into its composition. The arms

and armour of the ancient nations, their implements of agriculture, with much of their domestic and temple furniture, were of copper, hardened with tin, as occasion required.

Pure copper is of a reddish-brown colour, and, except titanium, no other metallic substance exhibits this hue. It closely approaches to iron in its numerous adaptations to the purposes of common life, but unlike that metal, solutions of which are a valuable medicine, those of copper are highly poisonous. Besides being used for coin, sheathing the bottoms of vessels, parts of machinery, a great variety of utensils, and for engraving, it is capable of forming alloys with other metals of great value. Mixed with zinc, it forms *brass*, the material of most philosophical and astronomical instruments, of many parts of almost every machine, and of the humble, but most useful domestic article, pins. Mixed with tin, it forms *bronze*, which the ancients cast into statues of enormous dimensions, and made into tools. A small bronze knife, found at Thebes, after being buried at least two thousand years, had its edge so perfect, that it was used for a penknife for several months after its exhumation. The metal of the four celebrated statues of horses, taken from Constantinople to Venice in 1204, and set up in the portal of St. Mark, transported by the French to Paris in 1798, and finally returned to their ancient pedestals in 1815, consists of nine hundred and ninety-three parts copper, and seven tin, according to the analysis of

Klaproth. *Bell-metal*, the material of "the church-going bell," consists of three parts of copper to one of tin, with an addition of zinc, antimony, and silver, which improve the sonorousness of the product; *speculum metal*, so called from its employment for optical purposes, is composed of copper, tin, and silver, with a little zinc and arsenic; and the imitations called *German silver*, are alloys of copper with tin and nickel.

Lead.

This useful and abundant substance differs from the sonorous copper in being one of the metals most destitute of that quality, but agrees with it in the poisonous nature of its acids. It is found in a vast variety of combinations, but they are almost all objects of interest merely to the mineralogist, except galena, a rich sulphuret, from which the lead of commerce is derived. The ore occurs in veins most plentifully in the mountain-limestone districts, and usually contains some proportion of silver, often in sufficient quantity to pay the expense of separating it. In the north of England, the proportion ranges from two to twenty-four ounces of silver per ton of ore; but in Cornwall as much as a hundred ounces per ton have been obtained, and even a hundred and forty ounces at the Beer Alston mines, in Devonshire. Lead is one of our most valuable metallic products, and has been procured in considerable abundance for several centuries. It distin-

guishes Saxony, Bohemia, and Spain; and very rich lead mines are now worked in the western section of the United States. Through a district extending nearly ninety miles from east to west by upwards of fifty miles from north to south, embracing parts of Wisconsin, Iowa, Illinois, and Missouri, there is scarcely a square mile without indications of the ore.

In the song which commemorates the destruction of Pharaoh and his host, the first mention of the metal occurs: "They sank as lead in the mighty waters." Job wished that a perpetual memorial might be made of his words, by being "graven with an iron pen and lead in the rock for ever"—an allusion either to the practice of engraving records on leaden tablets, or of pouring the melted metal into letters cut in stone, to render the inscription more obvious.

Lead has a bluish-grey colour, and exhibits a strong metallic lustre in a melted state, or when newly cut; but owing to its affinity for oxygen, the surface speedily tarnishes on exposure to the air, and assumes a dull earthy aspect. It is malleable, being reduced with ease into thin plates; ductile, and may be drawn into fine wire; but it has very little tenacity, the wire breaking at a comparatively trifling weight; and it melts at the low degree of 612° of Fahrenheit. The metal is employed for roofing, lining reservoirs, conducting water and gas, and the wealthy commit their relatives to the grave in coffins of this material. *White lead* and *red lead*,

used in painting, enamelling, and other arts, and *sugar of lead*, employed in medicine and dyeing, are preparations of the metal. *Pewter* is a compound of lead and tin; *shot* is composed of lead alloyed with arsenic; and the *type* or *stereotype* of the printer is formed of lead, tin, and antimony.

Tin.

Of the metals extensively employed in common life, this has the most confined geographical distribution, being only known to exist in a few localities, though usually abundant at the spots where it is found. It is never met with in nature otherwise than in the form of ore, of which there are but two species, and one is principally a mineralogical curiosity. The common ore consists of tin in combination with oxygen, small proportions of other metals, and earthy matter. It occurs in veins traversing granite, gneiss, and mica slate, also disseminated in granite, and in the alluvial soil of low grounds. In this last situation, the name of "stream tin" is applied to it, as a product transported by the agency of water from the rocks in which it was originally imbedded, along with the associated sands and gravels. Cornwall yields the largest supply of the metal of any part of the globe; after which the most prolific site is Banca, in the Indian Archipelago; Bohemia, Saxony, Chili, and Mexico, being other foreign localities.

Cornish tin is derived from both the sources

referred to, veins in the rocks and superficial deposits. The latter sites, which yield the purest tin ore, are called "stream works," because running water is employed to separate the ore from the lighter earthy substances with which it is intermingled. The lower parts of the valleys, and cavities in the moors, are occupied with debris, washed from the different lodes in adjoining rocks by successive floods. In the neighbourhood of St. Austle there are several stream works, the principal one, called Happy Union, being in the valley of Pentuan, a continuation of St. Austle Moor, where for ages a considerable quantity of tin has been obtained. The valley, varying in breadth from three hundred to six hundred feet, contains an accumulation of gravel, sand, and clay, extending in some places to the depth of sixty feet. The tin ground is the lowest part of this mass, and rests directly on the solid rock. The ore occurs in the form of coarse sand, and of pebbles of different sizes, up to ten pounds' weight. Banca tin is procured entirely in the same way, and the quantity of ore brought down by torrents from the stanniferous mountains may be imagined from the fact, that from three to four thousand tons of tin have been exported annually from that island alone.

Tin is first historically noticed as one of the metals found among the spoil of the Midianites, in the time of Moses, which were to be purified by fire. It has a brilliant white colour, melts at the temperature of 442° of Fahrenheit, possesses

little tenacity or ductility, but is very malleable, being beaten into the thin leaves called *tin-foil*, extensively used in the arts. Its appliances by itself are but few, the principal consumption being in the preparation of tin-plate, which is iron or copper coated with tin, the material of many household articles. This process has not been known in England two centuries, having been introduced about the year 1665, from the Saxon works in the Erzgebirge. In combination with other metals, tin forms valuable substances, some of which have been mentioned in connexion with copper and lead. *Britannia metal* is a mixture of tin, antimony, copper, and brass. *Mosaic gold*, used for gilding light wares, is a compound of tin and sulphur. Solutions of tin in various acids are employed in dyeing for fixing the colours.

Mercury.

This metal is remarkable for being fluid at an ordinary temperature, a property belonging to no other metallic substance. Hence the name commonly applied to it, *live* or *quick* silver, a translation of the old Latin name, *argentum vivum*, alluding to its mobility and brilliant silvery aspect. A temperature of 72° below the freezing point is required to render mercury solid. In this state the traveller Pallas saw it at Krasnoyarsk, on the Yenesei; and at Yakutsk it is a solid body at mid-winter for two months on the average. This fact not only evidences the intensity of

cold in Siberia, but the little dependence of climate upon latitude, the former place corresponding in latitude to that of Edinburgh.

Mercury is a rare metal, only occurring in any considerable quantity at a few places. It is found fluid, in globules, in most of its localities, but a very trifling amount is obtained in that state, the supply being drawn from one of its ores, cinnabar, a sulphuret of the metal, of a red colour, and in fact identical in its ingredients with the artificially prepared paint, vermilion. The richest mines are at Almaden, in Spain, a small town of La Mancha, situated in the range of the Sierra Morena. They yield annually between two and three millions of pounds of metal, and nearly a thousand workmen are employed in operations underground and at the surface. An important supply is drawn from China, from Idria, in the Austrian empire, and from Huancavelica, on the Andes of Peru. Small proportions are produced in Sweden, Hungary, and the ancient district of the Palatinate, on the Rhine. Owing to its fluidity, mercury is transported in iron jars, leather bags, or, as from China, in short joints of the bamboo.

The earlier writers of antiquity make no mention of mercury, and nothing is known of its first discovery. Dioscorides and Pliny refer to it as familiar in their time ; the former gives a method of obtaining it by sublimation from cinnabar ; the latter describes it as existing native in the mines of Spain, and was aware of the readiness with which it combines with gold.

Owing to this property, its most extensive consumption is in the beautiful process of amalgamation, by which the precious metals, entering freely into combination with it, are extracted from their ores, the mercury being subsequently separated from them with ease by distillation. It is used also in the manufacture of various articles, vermilion for paint, the colouring of sealing-wax, silvering of mirrors, the thermometer and barometer. The *calomel* of medicine is a compound of mercury and chlorine. A similar compound, but with differing proportions, produces the deadly poison, *corrosive sublimate.*

In addition to the metals which have been described, the longest known, and the most extensively useful, there are several others of important, though subordinate, service to society. These are, *antimony*, employed in medicine, and as an alloy, also in giving a yellow colour to glass and earthenware, one of its ores being probably the pigment which the ancients used in staining the eyelids, a custom of the eastern women at present, as old as the time of Jezebel; *manganese*, known only since the year 1774, though widely diffused in minute quantities, chiefly devoted to the production of chlorine for bleaching; *zinc*, commonly found associated with lead ore, and supplanting that metal in many of its purposes, owing to its greater cheapness, hardness, and capability of being worked with facility into any shape; *platinum*,

so called from *plata*, silver, in allusion to its appearance, discovered in 1741, the heaviest, most ductile, and infusible of all metals, of which many chemical vessels are made, owing to its resisting the action of destructive agents; *cobalt*, best known for its oxides giving to porcelain and pottery-wares their beautiful blue colours; *chromium*, compounds of which form admirable pigments, orange-yellow and emerald green; *bismuth*, used as an alloy in various metallic mixtures; and *arsenic*, employed in making flint glass, in dyeing and pyrotechnics, a deadly poison, but in proper quantities a useful medicine. The remaining metals have little or no practical application as yet in the affairs of life, though objects of interest to the chemist.

The processes by which the metals are extracted from their ores, and reduced to a state of purity, are complicated and laborious. A general idea of their nature may be formed from remarks in the preceding pages, and it belongs not to the province of mineralogy to give fuller details. Though metallurgy dates from a very early age in the principles upon which it proceeds, yet in their practical application the most advanced of the ancients were far behind the moderns. The pages of the classical writers abound with allusions to the art. It is also frequently referred to by the sacred penmen; but with a higher end in view than literary adornment—that of giving point and illustration to some important truth, or

providential movement. The noble declaration of Job, "He knoweth the way that I take, when he hath tried me I shall come forth as gold," refers to the metal undergoing the ordeal of the furnace, and there being set free from its alloys, while unconsumed itself—a beautiful image of the effect of sanctified affliction, and of the stability of religious principles. The "fine gold"—the "gold seven times purified"—are metaphorical phrases of similar significance. Thus, also, the office of the Messiah, to redeem from iniquity, through his atoning death upon the cross, and the purchased dispensation of his grace, is represented by the "refiner's fire," the "refiner and purifier of silver," purifying "the sons of Levi," and purging them "as gold and silver." The strivings of the Spirit, the appeals of the written word, the chastisements of Providence, and the instructions of the ministry, have for their end and aim the accomplishment of this all-important object—the cleansing of our corrupted nature from the dross of sin, the removal of the base and ignoble elements which deform it, in order to be "fitted for the Master's use." This is the true nobility of man—his highest honour and his greatest bliss. With it, however poor in worldly circumstances, he is rich in spiritual and eternal wealth; and without it, though commanding temporal opulence, he is really impoverished, dishonoured, and unblessed.

CHAPTER VI.

COMBUSTIBLE MINERALS.

Sulphur—The diamond—Graphite—Amber—Bitumen—Petroleum—Naphtha—Coal—Its varieties—Vegetable origin—The coal measures—British coal fields.

THE class of substances now to be reviewed range from some of the softest to the hardest in nature. But, however different in their external characters, they have for their principal constituent either sulphur or carbon, and are distinguished by being more or less inflammable.

Besides being widely diffused as an element in various bodies, *sulphur* occurs as a distinct mineral, in a nearly pure state. It then exhibits a citron-yellow colour, but frequently acquires a red, brown, grey, or green tinge, from slight traces of foreign ingredients. Its great repositories are either beds of gypsum, and their associated masses of rock salt, or the neighbourhood of active and extinct volcanoes, where it appears in the form of crusts and stalactites on the surface. In the former situation it is found near Cadiz in Spain, Cracow in Poland, and the valley of Noto and Mazzaro in Sicily; in the latter, it is met with in con-

siderable abundance near Naples, in Sicily, the Lipari Islands, and the Sandwich Archipelago. It is also deposited by some of the Icelandic hot springs, and appears sparingly in certain metalliferous veins. Sulphur or brimstone burns with a bluish flame at a low temperature, emitting a strong suffocating odour. On account of its inflammable nature, the prophet Isaiah refers to it, when picturing the certain and fearful doom of the ungodly, under the image of a pile of wood to be destroyed :

> "For Tophet is ordained of old;
> Yea, for the king it is prepared;
> He hath made it deep and large:
> The pile thereof is fire and much wood;
> The breath of the Lord, like a stream of brimstone,
> doth kindle it."—xxx. 33.

The principal use of the mineral is in the manufacture of gunpowder, sulphuric acid, casts, cements, and various medicinal preparations.

Carbon, the prime constituent of the vegetable kingdom, is extensively diffused through the mineral, and appears in its purest form in the *diamond*, the hardest substance with which we are acquainted, and the most valuable of gems, always found in detached crystals. It possesses the power of refracting light to a very high degree, the cause of its lustre, and is remarkable for giving out light, if exposed to the solar rays, and transferred to a dark place. There are specimens of various tints, rose-red and yellowish green, while some are black and opaque; but the colourless varieties, perfectly

transparent, are the most highly esteemed, and are valued at an enormous price when of a certain size. Composed entirely of the essential principle of vegetation, sir D. Brewster has advanced the opinion, "that the diamond originates, like amber, from the consolidation of, perhaps, vegetable matter, which gradually acquires a crystalline form, from the influence of time, and the slow action of corpuscular forces." If this be correct, nature may now be carrying on a diamond manufacture; and, indeed, it has long been the prevalent popular belief in the East Indies and Brazil, that diamonds are still produced. It is a surprising fact, which completely baffles the ingenuity of man to explain, and which may therefore teach him humility, that this precious product and the homely charcoal, so widely differing in every external quality, are both essentially composed of the same elementary substance.

Diamonds are found imbedded in compact strata, but are usually washed from loose alluvial soils. The finest specimens have been obtained in India, Borneo, and Brazil, and are crown jewels. It was supposed that they were peculiar to inter-tropical countries, till recently discovered in the Russo-Asiatic provinces. When Humboldt started on his celebrated journey into central Asia, he was so convinced that the same district which yielded gold and platinum contained diamonds, that before leaving Petersburg he told the empress she might expect some Russian specimens on his return.

Accordingly, on reaching the Ural mountains, he visited the gold-washing districts, and a diligent search for the valuable gem commenced. It was not crowned with immediate success, and the traveller pursued his journey. But four days after his departure, on the 5th of July, 1829, Paul Popoff, a boy of fourteen, one of count Polier's serfs, found the prize in the mines of Bissersk, and obtained freedom as his reward. This was the first-discovered Russian and European diamond, the mines being on the European side of the mountains. Another was soon obtained at the same site, which was forwarded to Humboldt, who was thus enabled to perform his promise to the empress on his return to the capital.

The weight of diamonds is estimated in carats, each being equal to between three and four grains troy weight. Transparency and colour are the other elements of value. The most celebrated examples, except one in Borneo, are the property of the European sovereigns. The great Russian diamond, placed at the top of the imperial sceptre, weighs 193 carats, and is as large as a pigeon's egg. It formerly adorned the throne of Nadir Shah, on whose death it was stolen, and afterwards disposed of, at a cheap rate, to an Armenian merchant named Shafras. He sold it to the empress Catherine II. for 450,000 rubles, about £70,000, a pension, and letters of nobility. Another account states, that it originally formed one of the eyes of a Brahminical idol, and was carried

off as plunder, an event which might have ante-dated its transfer to the throne of Persia. The Pitt, or Regent diamond, now the property of the French crown, is of smaller size, weighing 136 carats, but of greater value, being more perfect. It was purchased in India for a large sum by Thomas Pitt, the governor of Madras, and resold to the regent duke of Orleans, in 1716, for about £80,000, but it is estimated to be worth £140,000. It was at first set in the French crown, but affixed by Napoleon to the sword of state, its present post. The Austrian diamond, inferior to the two mentioned, weighs 139 carats, has a light yellow tinge, and was originally purchased for a few pence, at a stall in the market-place of Florence, as a piece of rock crystal. Its value being discovered, it passed into the hands of the grand duke of Tuscany, and with him to the crown of Austria.

These were the most celebrated diamonds in Europe down to the year 1850, when the Koh-i-noor, or "mountain of light," was brought from India, as the property of the British sovereign, exceeding the others in size and value. It was found in the year 1550 in the Deccan, was long the pride of the great Mogul, and after being possessed by the Afghan rulers and Runjeet Sing, was added to the royal treasures of Great Britain, upon the annexation of the Punjaub to our Indian empire.—Besides serving as an extravagantly estimated ornament, and illustrating that "pride of life" which leads to a shameful expenditure of

means, the diamond is applied to some real use, in engraving and cutting glass, in polishing by its powder, and forming the more delicate parts of mechanism.

Carbon, with a variable quantity of iron, constitutes *graphite*, a name referring to its property of leaving a trace on paper, and its extensive use as a writing or drawing material, derived from the Greek, to write or draw. It is commonly called *plumbago*, or *black lead*, but most inappropriately, as it does not contain the slightest trace of the metal. Fine varieties of the mineral are rare, but it occurs in the greatest perfection in Cumberland, from which the supplies are drawn for our lead pencils, as they are familiarly styled, known abroad as *Crayons d'Angleterre*. The mines are situated at the head of Borrowdale, on the side of Seatoller Fell, about eight miles south of Keswick. The period of their discovery is unknown, but the traditions of the county report, that a large oak being blown down during a violent storm, fragments of the rock where it had grown were torn up with the roots, which disclosed the material. When thus found, it was for some time only employed to mark sheep. As its uses became known, the rarity of the mineral led to the place being regularly worked and rigorously watched. Owing to a fraud attempted by the owner of a contiguous part of the mountain, who secretly sunk a shaft, and then opened a passage diagonally to the mines, an act of parliament was passed in the reign of George II. specially

for their security, in which the mineral is spoken of, as "discovered in one mountain or ridge of hills only, in this kingdom," and as having been found by experience "to be necessary in the casting of bomb-shells, round shot, and cannon balls." It is found in irregular masses, and now worked for harmless objects, chiefly the manufacture of pencils and polishing.

Another interesting product, *amber*, consists mainly of carbonaceous matter, and is undoubtedly a resin of the vegetable kingdom, like the gum which we see exuding from the trees in the orchards of the present day, but indurated and mineralized. This is inferred, both from its native situation, often found depending from fossilized trees, and from the occurrence of insects incased in it. Of these insects, some appear evidently to have struggled after being entangled in the then viscous fluid, and occasionally a leg or wing is found some distance from the body, which had been detached in the effort to escape; frequently, also, a wing or leg is found alone, which plainly the insect had broken off in its partially successful attempts to release itself. The mineral is met with in minute quantities in almost every country; in our own, at Highgate Hill, Brentford, and on the Goodwin Sands; but its grand repository is the Pomeranian shore of Prussia, where it is obtained in abundance, and has been collected from a very early date. As the property of the government, its collection was formerly intrusted to a public

officer, and the annual produce sold by auction; but it is now farmed out at a yearly rental. The amber may be dug along the strand between Dantzic and Memel; but it is chiefly thrown up by the sea, after a continuous north wind. "It is a remarkable fact, that as far back as tolerably correct accounts can be procured, or for three centuries, the quantity of amber collected on the southern shores of the Baltic has remained nearly constant, varying but little from a hundred and fifty hogsheads. The inhabitants of Königsberg, and of the other towns along those shores, have every reason to lament the existence of the precious commodity, which makes their strand and sea-side fields too sacred for them to walk upon, the rigorous jealousy with which the amber coast is guarded, subjecting everyone who ventures on the forbidden ground to the annoyance of search and detention." The mineral varies from a delicate straw colour to a deep yellow. It is employed for ornamental purposes, and large fine specimens are highly valued. In the Royal Museum at Berlin, there is a mass weighing eighteen pounds, the largest known specimen, found in Lithuania. The ancients were well aware that amber developed in a high degree electrical susceptibilities, and from the name applied to it by the Greeks, *electron*, we have derived our word electricity.

The highly inflammable bituminous products, occurring solid and fluid, have carbonaceous matter in alliance with hydrogen for their base.

Bitumen itself, or *mineral pitch*, the solid form of the substance, presents several varieties, caused by slight differences of composition. The colour passes from dark brown into deep black, and the texture is varyingly soft, elastic, and compact. One of its most remarkable localities is in the island of Trinidad, where there is a lake of bitumen, of unknown depth, and three miles in circumference. It is solid and cold near the shores, but gradually becomes warm and soft towards the centre, where it is boiling. The appearance of the solidified bitumen is as if the whole surface had boiled up in large bubbles, and then suddenly cooled. The ascent to the lake from the sea, a distance of three quarters of a mile, is covered with the hardened pitch, on which trees and vegetation flourish, and occasionally the masses of the mineral rise like black rocks among the foliage. Compact bitumen is commonly called *asphaltum*. It occurs abundantly in Palestine, on the shores and surface of the Dead Sea, which, from that circumstance, is frequently styled the Lake Asphaltites, the Germans denominating the product *Juden-pech*, or Jew's pitch. Bitumen was used in very early times as a cement, a fact stated in the account of the building of the Tower of Babel, and attested by the existing remains of Babylon. It was also employed as a coating for boats on the Nile and Euphrates, being impenetrable by water. It is still used for these purposes in the east, also to cover tanks, the floors of bath-rooms, and mixed with

a proportion of sand or earth, it serves to form the terraced roofs of houses.

In *petroleum*, rock or mineral oil, bitumen appears in a fluid state, and more free from earthy ingredients. It oozes from certain rocks of the coal formation, with somewhat more consistency than common tar. *Naphtha* is the same substance, more pure and limpid. It issues out of the earth in large quantities, near Rangoon, in the Burman empire, in various parts of Persia, and in Turkish Kourdistan. The oil is employed medicinally, as an embrocation, also in the manufacture of varnish, the formation of oil paint, and for lighting. In Persia, rags saturated with naphtha being burned in an iron frame a few feet from the ground, thoroughly illuminate the court of a khan, or other inclosure. On exposure to the air, naphtha deepens in colour, increases in consistency, and passes into petroleum, which, similarly exposed, gradually becomes solid bitumen.

We have now to notice the well-known material, *coal*, perhaps the most important of all the mineral treasures of the earth, since without it the metalliferous ores would be comparatively valueless, for want of the fuel necessary to their reduction into pure metal.

Of this precious product, *anthracite* is a non-bituminous species, variously called "stone coal" in Staffordshire, "Welsh culm" in South Wales, "blind coal" in Scotland, and "Kilkenny coal" in that locality of the sister kingdom. Owing to the absence of bitumen, it ignites

with difficulty, and hence its stores are comparatively untouched in our own country, not being used in domestic life. But in the northern United States, where common coal is rare, anthracite is the principal fuel, and is preferred to the bituminous kind, as it burns with very little flame and no smoke or odour. Hence the murky atmosphere of the English cities is there unknown. Immense deposits occur, the most celebrated of which is the great anthracite region of the Susquehanna, an elongated narrow basin, extending between sixty and seventy miles, through which the river flows. The coal crops out of the sides of the hills in enormously thick beds, which, being nearly horizontal, are worked without much downward excavation. The works appear like vast caverns, whose roofs are supported by thick columns of the unremoved material, "into which a coach and six might be driven and turned again with ease."

There are several varieties of common bituminous coal. The principal are *caking coal*, the prevalent kind in the Newcastle field, so called from the detached pieces uniting in a solid mass when heated, *splint* or *hard coal*, prevailing in the Staffordshire and Scotch districts, named from its splintery fracture, deriving hardness from the intermixture of earthy matter; *cherry coal*, occurring in the same districts, and so named from its beauty and lustre; and *cannel coal*, obtained in comparatively small quantities, the name being derived from the word candle, because in some places it has been used as a

substitute. Sometimes these varieties are found in the same mine. The last-mentioned, receiving a polish, is occasionally made into inkstands, small boxes, and other similar articles. *Jet*, worked into trinkets, differs very little from it, except in its deeper black and more brilliant lustre. *Lignite*, also styled *brown coal* from the colour, widely varies from the common product, occurs apart from its localities, and appears to be wood or peat passing into a mineralized and bituminous state. It emits an offensive odour in burning, yields but a weak flame, and is only used in districts where no other fuel can be obtained.

Coal embraces a great number of elementary substances, but its leading constituents are charcoal, the purest form of carbon, and bitumen, with which earthy matter is intermixed. The varieties result from the different measures in which these ingredients are combined. A large portion of bitumen produces the highly combustible Newcastle or caking coal; and when it occurs in small proportions, while the amount of earthy matter is increased, the hard variety is the product, which is less readily ignited, and leaves a considerable quantity of ashes. That coal is nothing more than vegetable matter, which has undergone a certain mineralizing process, is now generally admitted, and may be very clearly proved. If ashes taken from a fire are placed under a microscope, the remains of tubes and fibres will commonly be detected, though of course the great mass of the vegetable

structure has perished during the combustion. It is difficult to imagine evidence more convincing of the fact in question. All the varieties of coal that have been described are found in seams or beds, interstratified with sandstones, shales, clays, and limestones; and most commonly there are several seams of coal at the same spot, separated by these masses. The associated beds are known in practical mining as the "coal measures," and the tract of country where they exist as a "coal field." The total thickness of the measures in South Staffordshire does not exceed 350 yards, in Yorkshire it ranges from 1,000 to 1,500, and in Lancashire it is said to be still greater. The total thickness of the coal itself is generally about 50 or 60 feet, usually divided into 20 or more seams, varying themselves in thickness from a few inches to 6 feet. But in some districts, Staffordshire and Ayrshire, several seams so closely overlie each other as to constitute one mass, from 30 to 40 feet thick.

Two facts have been clearly ascertained with reference to the position of coal—that, both in Europe and America, it is almost absolutely limited to one kind of strata, the mountain limestone and its associate rocks, hence styled the carboniferous system; and that coal occurs in abundance and of excellent quality beneath large tracts of country, where few or no indications of its existence appear at the surface. The mineral is widely distributed, and occurs in immense deposits, the working of which, except

in parts of Europe, is yet in its infancy. The great producing countries are in order—

Great Britain furnishing annually	31,500,000	tons.
Belgium	4,960,077	„
France	4,141,617	„
United States	4,400,000	„
Prussia	3,500,000	„
Austria	700,000	„

The superiority of our own country in this table is not due to the possession of an actual amount of coal greater than many other regions, but evidences the extraordinary scale upon which our stores are developed. The coal formation of the United States embraces 133,132 square miles, while Great Britain possesses only 11,859 square miles. Nor among material causes of prosperity is it the immensity of the produce which has contributed to acquire for a country so insignificant in territorial extent the political status of a first-rate power, so much as its favourable position in connexion with equally abundant iron ores and limestones, and its ready accessibility to the sea.

There are seventeen coal districts of local importance in England and Wales, five of which claim attention on account of their extent, or of the great scale upon which they are worked.

1. The Northumberland and Durham field extends from the river Coquet on the north nearly to the Tees on the south, and is intersected by the two navigable rivers, the Tyne and Wear. It is about fifty miles in length, by twenty-two miles in breadth, stretching that distance inland from the coast, and its area is

calculated at about eight hundred square miles. The coal is reached at a very varying depth from the surface, the same bed which lies at the great depth of twelve hundred feet under Jarrow Lake, being little more than forty feet from the ground at another place near Jarrow. It is wrought almost entirely for sale, and only to a very small extent for the manufacture of metals, no iron-stone being associated with it. The tract supplies the two counties in which it is situated, contiguous parts of Scotland, the North Riding of Yorkshire, the whole of the eastern and southern coasts of England as far as Cornwall, including the metropolis, and the export to foreign parts is also very extensive.

There are as many as forty distinct seams of coal in this field, but only eighteen of them are considered workable, or sufficiently thick to remunerate by their produce. The trade has been in existence for upwards of six centuries, the first charter granted to the town of Newcastle for digging coals dating in the year 1239, during the reign of Henry III. But in 1306, its use was prohibited in London by royal proclamation, chiefly because it injured the sale of wood for fuel, great quantities of which were then growing around the city. According to Mr. Taylor, at the commencement of the London coal trade two ships were sufficient for the business. In 1615, 400 sail were employed; in 1703, the number amounted to 600; and in 1841, the home and foreign trade of the northern coal field was conducted by not less

than 6,873 collier brigs. In 1846, there were 10,488 ships' cargoes entered for duty in the port of London. The largest quantity of coal sold in the London market in one day took place October 21st, 1844. There were 282 cargoes disposed of, amounting to upwards of 80,000 tons; and at the price then obtained for the article, this one day's business represented £80,000 sterling. Notwithstanding the enormous annual produce of the northern field, it is a very moderate calculation of its resources, to suppose that the present supply can be kept up through the next four centuries.

Some of the northern coal seams are remarkable for evolving a vast quantity of gas, the cause of many fearful accidents, and occasionally of singular appearances. A few years ago, the surface of the river Wear, at Durham, while unruffled by the wind, was observed to be in a state of ebullition, occasioned by numerous streams of air-bubbles issuing from below. It was conjectured that the air would prove to be the light carburetted hydrogen gas, generated in abundance in the strata of the district, which had opened a fissure in the bed of the river, in order to escape from subterranean confinement. Upon a boat being moored alongside the principal jet, its inflammable nature was fully ascertained by the application of a lighted taper. A large inverted funnel being fixed over the supposed fissure, furnished with a pipe of the requisite length, a sufficient amount of gas was thus collected to produce a large and

brilliant flame, arising, as it were, from the bosom of the "old river of Wear;" and thousands crowded to see the extraordinary spectacle, apparently of a river on fire.

2. The great coal field of Lancashire extends from Colne and Preston on the north, by Rochdale and Manchester, southward into the eastern parts of Cheshire. It is wrought upon an extensive scale for the supply of the great manufacturing establishments upon its surface, and the domestic use of the vast population congregated in the locality.

3. The Yorkshire coal field embraces a considerable part of the West Riding, and stretches southwards along the borders of the counties of Derby and Nottingham. It supplies with fuel a wide area of country, and has a considerable home consumption in iron-works. At Lower Haugh, near Rotherham, there is an extensive bed on fire beneath the village, which has been burning with more or less intensity upwards of twenty years. The coal coming to the surface in certain places was originally ignited by a fire for burning stones intended for road materials. The subterranean fire has continued to advance in various directions, its progress being manifested by the appearance of smoke at intervals at the surface, and a feeling of apprehension as to the ultimate fate of the village has long been prevalent. In several large tracts, the ground is a perfect hotbed; but where the heat is not so intense as to destroy vegetation, advantage is taken of it by the villagers to raise early crops

of vegetables for the adjoining markets. Owing to this unnatural state of the soil, the inhabitants are strangers to a pure atmosphere, and in the worst localities the houses are often filled with warm air, charged with sulphur, rendering them as habitations little better than a coal pit.

4. The field of South Staffordshire, lying to the west and north of Birmingham, is limited as to its area, forming a mere speck on the map of England, but very remarkable for its immense beds of mineral wealth, coal and ironstone, and the consequent density of its population. So much has the country been perforated, that it may be aptly compared to a vast rabbit warren. Instances of the subsidence of land, causing houses to fall down, or so to decline from the perpendicular as to render them unsafe, are of very common occurrence. The Report of the Midland Mining Commission mentions a newly-erected church and parsonage-house being composed of wooden framework, which will admit of their being screwed up into the perpendicular again whenever they may be thrown out of it. Near Dudley, early vegetables are raised for the metropolitan market on ground heated by steam and smoke, which proceed from an old colliery, which has been on fire for many years, and which may be observed bursting through crevices of the rock on the side of the road close to the town.

The external characteristics of this region are truthfully sketched in the Report just named. "The traveller appears never to get

out of an interminable village, composed of cottages and very ordinary houses. In some directions, he may travel for miles, and never be out of sight of numerous two-storied houses, so that the area covered by bricks and mortar must be immense. These houses, for the most part, are not arranged in continuous streets, but are interspersed with blazing furnaces, heaps of burning coal in process of coking, piles of iron-stone calcining, forges, pit banks, and engine chimneys; the country being besides intersected with canals, crossing each other at various levels; and the small remaining patches of the surface soil occupied with irregular fields of grass and corn, intermingled with heaps of refuse of mines, or of slag from the blast furnaces. Sometimes the road passes between mounds of refuse from the pits, like a deep cutting on a railway; at others it runs like a causeway, raised some feet above the fields on either side, which have subsided by the excavation of the minerals beneath. In one place, observing that the turnpike road sloped a good deal on one side, I asked the driver if it would not be repaired, to which he replied, that they were still working the coal beneath it, and that they would probably wait to see if the road would not right itself by sinking on the opposite side, and so become level again." Nothing can be more complete and striking than the transition from this district to the localities which surround it. The colour of the roads and the character of the trees are

different. Tall chimneys and pit banks are replaced by wooded hills and green meadows. The atmosphere clears and freshens, losing its clouds of smoke and sulphurous odour. The flail of the husbandman supersedes with its stroke the clang of the forge hammer, and the singing of birds succeeds to the sound of the steam-engine.

5. The South Wales field, stretching from the county of Monmouth to that of Pembroke, is as yet comparatively little worked, but is the most extensive of all our coal deposits. It contains a reserve of the product for use when the other tracts are exhausted, far greater than that which lay beneath the surface in the district of the Tyne and Wear, before a single hearth had been warmed by its produce.

With this notice of an invaluable product, now contributing to the comfort of ten thousand homes, our description of important minerals in detail closes. Their uses to man, and dissemination in the earth, strongly evidence the wisdom and goodness of his Maker. While all is apparent confusion and disorder in the structure of the terrestrial mass, a little examination shows the reality to be far otherwise, and evinces an enlightened and benevolent control exercised in the disposition of nature's insensate elements. It illustrates the bounty of Providence, that the most needful substances are precisely those which are most abundantly distributed and easily obtained; and it manifests wise design, that they are not so plentiful,

nor so readily procured, as not to demand patient industry and ingenuity, the exercise of which is indispensable to human improvement and happiness. Is it not, therefore, the reasonable service of creatures who have received much while deserving nothing, to recognise the paternal care of God in the works of his hand, to own it with gratitude, and to graft obedience upon thankfulness? Of old, the leader of the chosen people contemplated with pious satisfaction their possession of "a land wherein thou shalt eat bread without scarceness"—"a land whose stones are iron, and out of whose hills thou mayest dig brass"—"a land of brooks of water, of fountains and depths that spring out of valleys and hills"—"a land of wheat, and barley, and vines, and fig-trees." Such language, true of Palestine, applies with still greater force and peculiarity to Britain; and the duty enjoined upon the ancient race is specially obligatory to ourselves, "Thou shalt bless the Lord thy God for the good land which he hath given thee." But the Jew had higher benefits to acknowledge and improve than fertile soils, luxuriant harvests, and metallic stores, even the giving of the Law, the covenant of promise, and the mercy-seat; and superadded to great material advantages, it is our inestimable privilege to have the priceless blessings of the gospel of Christ in free and open proclamation. Over the length and breadth of the land, the glad tidings of a Saviour's love have been made known; the offer of redemption through his

blood, even the forgiveness of sins by faith in his name, is freely dispensed. The gospel, taught in all its native purity, forms the true riches of our beloved country. Personal happiness and national prosperity alike hinge upon the due appreciation of it. Let us wisely adopt, then, the conduct which our Lord plainly recommended in his parable, "The kingdom of heaven is like unto treasure hid in a field; the which when a man hath found, he hideth, and for joy thereof goeth and selleth all that he hath, and buyeth that field."

CHAPTER VII.

INCIDENTS AND PERILS OF MINING.

Injurious effects of quicksilver—The Idria mine—Fires in mines—Falling in of the roofs—Ordinary accidents—Negligence — Fire-damp — Choak-damp — Explosion at Felling colliery—Sir Humphrey Davy—The safety-lamp—Irruption of a river—Irruption of the sea—Recent explosion in Scotland—General remarks.

EVENTS of exciting interest or romantic character, with others of a most mournful nature, are prominent in the history of mining, at home and abroad. But, besides the frequent recurrence of direful accidents, a vast amount of suffering is engendered by the exhausting manual labour undergone, and the noxious gases inhaled, which rapidly affect the physical system, and conduce to premature age and death. Sometimes the very mineral itself is injurious to the constitution, as in the instance of quicksilver. At some of the Peruvian silver mines, the Indians are employed in separating the metal from the dross, by amalgamating quicksilver with the ore, accomplishing the operation of mixing them by the tramping of their feet for several hours in succession. The process is usually performed barefooted, and the consequence is, that paralysis and other diseases,

caused by the action of mercury, are very frequent. Where horses are used for the purpose, the quicksilver speedily has a fatal effect upon their hoofs, and after a few years the animals become unfit for work. But it is specially in the mines where the ores of quicksilver are obtained, and the metal sometimes occurs native, that its deleterious and deadly power upon the human frame is exhibited.

At the Idria quicksilver mine, the very persons of the workmen are penetrated by particles of the subtle metal, derived from the fumes disengaged from the ore. Though the precaution is taken by the labourers of holding in their mouths a piece of gold, in order to attract the poisonous product, for which it has a great affinity, and thus prevent its passage into the stomach, yet only partial protection can be thus obtained. Instances have been known of the metal so completely pervading the body, that it has been seen to exude from its pores. Nervous tremblings, convulsive distortions of the frame, violent pains in the bones, and a hideous complexion, are the effects commonly produced; and usually those who are doomed to be constantly under ground expire in about two years, from a total contraction of the joints. Some of the people employed are tempted to risk calamity by the lure of high wages, while others are condemned to it for their crimes by the Austrian government. A visitor of these pernicious caverns in the last century relates, that while walking after his guide, a voice

accosted him, and pronounced his name. "I turned, and saw a creature all black and hideous, who approached me, with a most piteous accent, demanding, 'Ah! E——, do you not know me ?' " This was the count Alberti, thus sentenced for fighting a duel under circumstances which exasperated the emperor, whose faithful wife, the daughter of a high family in Germany, voluntarily shared his bondage. Both were so changed in their appearance when a pardon released them from their subterranean dungeon, as to be scarcely recognised by their most intimate friends.

The town of Idria is about twenty-five miles north-east of Trieste, and the same distance west of Laybach. It occupies a deep valley, inclosed by high mountains. The pale unhealthy countenances of the inhabitants indicate the pernicious atmosphere they inhale, impregnated with the vapours of various preparations of mercury manufactured in the place. The whole district is said to be affected, so that near the town cattle cannot be reared, and neither fruit nor grain will ripen. One of the most remarkable events in its annals occurred in the year 1803, when the mine caught fire, and a terrible conflagration ensued, to which the whole of the works fell a prey. Attempts were made to smother the fire, but it burst forth with the fury of a volcano, shaking the ground and shattering the houses. It was only extinguished by turning the Idria stream into it, and flooding all the excavations. The loss to the govern-

ment was immense, and a long interval elapsed before the water could be so far reduced as to recommence the works. Owing to the action of the fire upon the ore, the interior of the mine exhibited a scene of dazzling splendour, the walls being lined and the floors carpeted with particles of quicksilver.

A similar accident happened to the great copper mine of Fahlun, in Sweden, towards the close of the last century, Some miners being disturbed while attempting to steal ore, left their torches behind them. These set fire to the timber-work, which communicated to the copper pyrites. The combustion rolled forth enormous volumes of sulphurous vapour. As it was found impossible to subdue it, this part of the mine was carefully shut off from the rest, and has continued burning ever since. Another event, not uncommon in subterranean operations, occurred at this spot in the year 1666. In consequence of the extensive galleries excavated, and sufficient care not being taken properly to support the roofs, a central superincumbent mass fell in, and laid that part of the mine open to the sky. A funnel-shaped opening was produced, like the crater of a volcano, and the resemblance became striking when the conflagration took place, volumes of smoke ascending through it. In South America, the lives of the Indian miners have been largely sacrificed by owners allowing excavations to proceed without the adoption of any measures of security, and the shafts to remain in a dangerous state. Upon

the latter falling in, the workmen are at once cut off from communication with the surface, and survive the occurrence to perish by a lingering death. The now ruined mine of Matagente, in Peru, obtained that name, literally meaning "Kill People," from three hundred labourers being destroyed in this manner.

Considering the scene of the miner's toil, it can excite no surprise that fatal casualties are far more common among that class than among those who labour on the surface; and of those whose daily occupation lies in deep and dark underground works, the collier is incomparably the most exposed to danger. The principal accidents to which such persons are liable are mentioned in the following table, many of which, though not including the most fearful, apply to miners in general. The table states the causes of death by violence in fifty-five districts of registration in our own country which contain mines, for the year 1838:—

Fell down the shafts	60
Fell down the shaft from the rope breaking	3
Fell out when ascending	3
Drawn over the pulley	6
Fall of stone out of a skif down the shaft	4
Drowned in the mines	22
Fall of stones, coal, and rubbish, in the mines	97
Injuries, the nature of which is not specified	41
Crushed in coal pits	2
Explosion of gas	80
Suffocated by choak-damp	8
Explosion of gunpowder	4
By tram wagons	21
	351

A considerable proportion of these accidents

belong to the easily preventible class, for ninety-one of the recorded cases of death resulted from falling down the shafts owing to the unguarded state of the pit's mouth, the badness of the ropes, the mismanagement of the drawing engine, and water being suffered to accumulate in the mines. Injury to persons going down or coming up a shaft, from stones and other materials accidentally falling, is very readily guarded against in some places by the use of what is called an umbrella, because resembling it in form, but composed of weighty solid iron, which effectually shields those beneath it. Descending a depth of seven or eight hundred feet, it is easy to see how much mischief may be caused by the fall of a body of only very slight weight where no such protection is provided. The employment of the young and inexperienced to tend the steam machinery which winds up people out of the pits, is another source of danger, to be obviated by intrusting the office to mature age and judgment, for if the engines are not stopped at the proper moment, the persons wound up are thrown over the beam headlong into the pit again. In fact, in most of the accidents occurring in coal mines, negligence forms an almost invariable element, which is fairly assignable to one or other of those who are concerned in this branch of industry—either to the colliers themselves being inattentive to those means of safety which are under their own control, or to the superintendents, and ultimately to the owners of the

mines, in not providing as far as possible the means of security.

But the great element of danger in coal mines is more unmanageable, and is still unsubdued, notwithstanding the application of the highest science to effect the object. This monster mischief is carburetted hydrogen gas, which, when mixed with a certain proportion of atmospheric air, explodes with great violence if accidentally set fire to, and involves in destruction every object in its path; it hence bears the local mining name of "wild-fire," or "fire-damp." The quantity of this gas generated is very variable. Some seams of coal pour it forth in great abundance, and are therefore called "fiery seams," the workings in which they are situated being styled "fiery mines." It is far more prevalent and formidable in our northern coal fields than in the southern; accumulates usually in old workings, or where ventilation is imperfect; and sometimes suddenly forces its way in vast volumes into the best ventilated mines, through crannies in the roof, sides, or floor, from cavities in the adjoining strata where it has collected. Cavities of this description are termed "bags of foulness," and are just as dangerous in the vicinity of lighted candles as powder magazines.

In the coal field of the Tyne, the Bensham seam is remarkable for its fiery character. "I simply," says one, "drilled a hole into the solid coal, and stuck a tin pipe into the aperture, surrounded it with clay, and lighted it, and

I had immediately a gas light; the quantity evolved from the coal was such, that in every one of those places I had nothing to do but to set a candle, and then could set a thousand fissures on fire. The whole face of the working was a gas pipe from every pore of the coal." In several collieries there are constant discharges of fire-damp, which are collected and conveyed to the surface in a pipe, and there securely ignited, draining as it were the coal of its dangerous element. At Wallsend, not less than eleven thousand hogsheads of gas per minute are consumed in this way, feeding a fiery streamer of from eight to nine feet long, which is thus kept constantly burning, the gas rushing out of the pipe with the roar of a blast furnace.

Being specifically lighter than common air, carburetted hydrogen gas tends to rise to the surface, and ascending to the roof of a lofty mine, it may float over the heads of the workmen without occasioning damage. But when a considerable volume becomes mixed with the air of the atmosphere, in the proportion of one-fourteenth part, the consequences are terrific if the mass is accidentally ignited by the candles or lanterns of the labourers. Instantly the mine is illuminated with the most brilliant lightning. The expanded fluid drives the flaming air with the velocity of a whirlwind to the shafts, tearing up everything in its progress, scorching the miners encountered to a cinder, burying others under enormous heaps

of ruin shaken from the roof, and exhausts its fury in a discharge of thick clouds of coal dust, stones, timber, and not unfrequently the limbs of men and horses, from the mouth of the pit.

There is another enemy to life present upon these dreadful occasions, which, though apparently less terrible, is equally as destructive, and commonly claims for its victims a number of those who have been so situated as to be spared by the fiery element. This is carbonic acid gas, variously called "after-damp," "black-damp," and "choak-damp," which is irrespirable, and destroys by suffocation. Being heavier than atmospheric air, this gas has no tendency to escape to the surface, and usually rests in a thin stratum upon the floor of the mine, where it occasions no mischief, being out of the way of the organs of respiration. But as the effect of an explosion of fire-damp is to exclude the atmospheric current for an interval from the workings, the after-damp at once issues from its secret recesses to fill up the vacuum created, and the survivors of the former are frequently overtaken by the latter before they can reach the shafts, or they meet it in their flight, and share in the general catastrophe.

The fire-damp and after-damp have slain their thousands. Places of interment in Durham, Northumberland, and Yorkshire, contain many a monument to the memory of scores who have perished together, marking the spot where their calcined and disfigured frames, recovered from

the pits, have found a common grave. Thus, in the chapel-yard of Heworth, near Gateshead, in the county of Durham, an obelisk indicates the site of an immense grave, in which eighty-seven sufferers repose, side by side, and two coffins deep, who were killed by an explosion in the Felling colliery in 1812; four others were buried in single graves, and the remains of another were never found. About half-past eleven o'clock on the morning of the 25th of May, the inhabitants of the neighbouring villages were alarmed by the well-known sound of explosion. The subterraneous fire broke forth with two heavy discharges from the John pit, which were immediately followed by one from the William pit, the names of the two principal shafts. A slight trembling, as if from an earthquake, was felt for about half a mile around the workings, and a report, like an unsteady fire of infantry, was heard to the distance of three or four miles. Immense quantities of dust and small coal accompanied the blasts, rising high into the air in the form of an inverted cone. The heaviest part of the ejected matter fell near the pits; but the coal dust was borne by a strong west wind over the adjacent country. In the village of Heworth it caused a darkness like that of early twilight, and covered the roads so thickly that the footsteps of passengers were strongly imprinted in it. These announcements of calamity were quickly responded to by the families and friends of the miners, who wildly rushed to the spot to

ascertain their fate. Out of one hundred and twenty-one persons underground, only twenty-nine were rescued; and such was the condition of the mine that search for the bodies of the deceased could not be regularly commenced till the 8th of July, and it was not till the 19th of September that the last was dug from under a heap of stones.

This melancholy occurrence has been mentioned because, along with a number of others about the same period, it originated strenuous attempts to obviate the danger from fire-damp, by the invention of a lamp which might be employed with safety in the midst of the explosive gas. In evidence before a committee of the House of Commons, in 1835, the circumstances of sir Humphrey Davy's visit to the Wallsend colliery in 1815, with this object in view, are thus related by Mr. Buddle :—

"I explained to him as well as I was able the nature of our fiery mines, and that the great desideratum was a light that could be safely used in an explosive mixture. I had not the slightest idea myself of ever seeing such a thing accomplished. After a great deal of conversation with sir H. Davy, and he making himself perfectly acquainted with the nature of our mines and what was wanted, just as we were parting he looked at me and said, 'I think I can do something for you.' Thinking it was too much ever to be achieved, I gave him a look of incredulity; at the moment it was beyond my comprehension. However, smiling,

he said, 'Do not despair; I think I can do something for you in a very short time.' To the best of my recollection, within fourteen days he wrote to me to say that he had made a discovery which would answer my object, namely, the procuring a safe light in an explosive mixture. In a few days he sent me down two of the Davy lamps, nearly like those at present used. On the strength of his authority I took the lamp, tried it first in an explosive mixture on the surface, and then took it into a mine, and it is impossible for me to express my astonishment and delight when I suspended the lamp in the mine, and saw it red-hot. If it had been a monster destroyed I could not have felt more exultation than I did. I said to those around me, 'We have at last subdued the monster.'"

The safety-lamp, or Davy of the miners, is a theoretically perfect instrument, constructed upon the principle, that the fire-damp requiring a stronger degree of heat to be exploded than common inflammable gas, the flame of a lamp will be rendered unequal to the task of explosion if surrounded by wire gauze with sufficiently small meshes. This beautiful discovery has been of high service, and entitles its author to national gratitude; but the lamp is practically inconvenient, owing to the little light afforded by it; and it has been unhappily so incautiously used, that upon the whole fatal accidents have increased in number and fearfulness since its introduction into mines.

The common use of the safety-lamp may be said to date from the year 1816. During eighteen preceding years, four hundred and forty-seven persons lost their lives from explosions in the counties of Northumberland and Durham; but in the course of the eighteen following years, the number increased to five hundred and thirty-eight. Various causes contributed to this lamentable result—the greater extent of the workings in the district—the excavation with the aid of the lamp of seams of coal so fiery as to have previously lain unwrought on that account—the idea entertained that upon its introduction the necessity for former precautions and vigilance ceased—and the excessive obstinacy and imprudence of the employed. Taking off the top of the safety-lamp for the purpose of trimming the wick while surrounded by fire-damp; working with a candle in fire-damp because the safety-lamp gave a dull light; carelessly swinging the lamp, which requires to be moved with caution, to and fro with the motion of the arm in removing it; and almost every other mode in which ignorance, recklessness, and folly can be manifested, have led to fatal casualties, and rendered the very instrument a fertile cause of accidents, which it was intended, and is unquestionably calculated to lessen. In the year 1839, when twenty-one lives were lost in one of the earl of Lonsdale's pits, not only was the folly committed of the men being allowed to descend before the foreman had ascertained the state of

the workings, but there was the almost incredible absurdity of a boy attending on him, carrying a safety-lamp in one hand for the sake of security, and a naked lighted candle in the other, as if for the sake of danger—and which was the cause of the catastrophe!

In the northern coal field, in well-regulated fiery mines, a safety-lamp, locked securely, is delivered to every miner, who is bound to deliver it back in the same condition, and is subject to a penalty in case of misconduct. The overman goes down every morning, and inspects every part of the works, before the men are allowed to proceed to their labour. The greatest care is taken to secure good ventilation, as the most effectual antagonist yet known of the destructive fire-damp. For this purpose an enormous furnace is kept burning day and night at the foot of a shaft, called the up-cast shaft, by which a powerful current of air is made to ascend, and consequently a corresponding current to descend a down-cast shaft to supply its place. The interior economy of the mine is carefully arranged, so as to convey this current of air through every part of it, in order that any explosive gas which may have accumulated may be carried off with it to the surface. Yet, with all these precautions, no long interval elapses without terrific explosions, and a sad waste of industrious human lives, nor does the cessation of such occurrences appear in the distant prospect. To render stringent regulations respecting ventilation compulsory

upon the owners and occupiers of mines, and to extend the system of rigorous public inspection, conducted by independent officials, seem to be the best precautionary measures which can be adopted. But until the cause of the mischief is conquered by some chemical agent being discovered, capable of absorbing or neutralizing the carburetted hydrogen generated, the miner will be in jeopardy every hour, since the momentary act of a thoughtless individual may utterly defeat all the prudence and care of his companions, or circumstances may occur to occasion calamity, impossible to anticipate and provide against.

An instance of the latter kind is made public as these pages pass through the press. It occurred at the Victoria coal pit, in the neighbourhood of Glasgow, on Saturday, March the 15th, 1851. The pit is stated to be of such a fiery character that as much gas might be accumulated by a single hour's interruption of the air courses, as would, when exploded, carry havoc throughout its subterranean area of seventy acres ; yet no danger was apprehended, for it was ventilated upon the most admirable principles, and the proprietors had spared neither labour nor expense to render it wholesome and safe. So convinced were they of its superiority in every respect, that a beautiful model of it, on the scale of a quarter of an inch to six feet, had been prepared for the great Industrial Exhibition, and was ready to be sent off at the time when the excavation, over which

theory and practice had jealously watched, was reduced to a wreck, accompanied by a wholesale destruction of human life. The works were then in full operation, turning out two hundred and forty tons of coal per day. The seam wrought was about six feet in thickness, and this constituted the height of the roof, which consisted of excellent limestone, mixed occasionally with small veins of alum shale. Not a finger had been scorched by fire-damp for a lengthened interval, nor was the use of the safety-lamp deemed necessary, except by the overman, when on his daily tour inspecting the mine.

Early in the morning, sixty-three workmen had descended in successive gangs to their several spheres of labour, preceded by the overman. Others stood round the mouth of the shaft, waiting their turn to go down, when the scene was suddenly changed into one of consternation and death by a terrific explosion. It continued nearly two minutes, gave several successive shocks or heaves, the first by far the loudest, until the pent-up vapour had expended itself, and then all was still. The colliers at the surface were thrown prostrate, but not injured. As soon as the shaft could be examined, it presented a spectacle of wreck and havoc which has seldom been paralleled on similar occasions. Woodwork had been blown up from the bottom, upwards of a thousand feet deep, and scattered all around the pit-head in a perfect shower. The same appearances were

presented at the mouth of the ventilating pit, situated at the distance of half a mile from the main down-shaft. This ventilating pit had been covered over with heavy timbers, and the air and smoke which ascended from it had been led, by a tunnel along the surface, to the bottom of a tall chimney, erected at a short distance, in order to increase the draught. But such was the force of the explosion, that it tore away the timbers as if they had been laths, and scattered them in fragments in every direction. In accounting for the occurrence, it is supposed that there must have been some sudden sinking in the roof of the pit. This might derange the ventilation, and enable the foul gas to accumulate, which would explode upon coming into contact with the lights of the workmen. Of the underground labourers, two only were rescued alive, crippled by the accident, and enfeebled by a subterranean detention of nearly two days. Fifty-three men and eight boys perished, making a sad total of sixty-one. This is by far the most fatal incident that has yet marked the history of mining industry in Scotland. It shows the inadequacy of the best human arrangements at present to master the danger in question, and points to a sphere in which genius and science may nobly exert themselves, endeavouring to devise some means of contending with it more successfully.

But, besides the outbreak of fire, the action of another element, a sudden irruption of water, must be added to the list of miners' perils.

Its accumulation in a vast body in abandoned and forgotten excavations, and the bursting forth of the deluge upon the reservoir being tapped in the course of new workings, have occasionally been very fatal incidents. An extraordinary accident occurred in one of the Scottish coal fields in the year 1833, which in a very brief space rendered an extensive mine useless, though happily involving no loss of life. In the month of June, two persons fishing in the river Garnock observed a slight agitation in the stream nearly opposite to them, which might have been mistaken for a disturbance caused by the leap of salmon, but for its continuance and the gurgling noise which accompanied it. Surmising that the bed of the river had given way, and that the water was rushing through the opening into one of the neighbouring coal mines, they hastened to the nearest pit to give the alarm, but the warning was received with incredulity. Its correctness was soon verified by the workmen making their way to the surface, some having with difficulty reached the bottom of the shaft, owing to the rapid influx of the water. Every effort was now made to fill up the opening in the river, but in vain, for it was enlarged until the entire body of the stream was engulphed, and its bed left dry for some distance below the chasm. At length, all the excavations, extending for many miles, were completely filled, and the Garnock resumed its usual flow. But now commenced a most remarkable spectacle. The

pressure of the water in the pits became so great, that the confined air, in the struggle to disengage itself, rent asunder the surface in a thousand places, till the whole was set free, the quantities of sand and water thrown up giving the appearance of boiling to a considerable area.

An analogous event, but of a fatal description, occurred in the year 1837, in the Cumberland coal field, which has long been remarkable for the extent to which the mines are carried under the sea, the depth of water above them being in some places sufficient for ships of large burden. The disaster arose from an irruption of the sea into the pits at Workington, near the mouth of the Derwent. It appears that the seam of coal rose under the sea, so that in working it every step brought the colliers nearer to the danger. The salt water oozed through, the noise of the waves was heard; an accident was foretold by many; and so great was the apprehension, that some of the persons employed left their work. Still the steward of the works, reckless of consequences, resolved to persevere. He discharged the foreman, who distinctly warned him of the peril, and tempted the men to stay by a higher amount of wages. The result may be given as it appears in evidence taken on the occasion: "The sea broke in on the 28th of July, 1837. They were working the pit out to sea, and towards the rise. They were nearly two miles under the sea from the shaft. They were continually getting nearer to the water as the workings were getting further

to the rise. It was a report among the men that there was some danger prior to the accident. There is no doubt that the pit was making salt water long before. Some got out. It happened in the night. None were left to tell how it happened, because where it broke in none escaped. The bodies were never recovered. The funeral service was read over the pit top. The place where the water broke in was discernible in the sea by the blackness of the spot. It appeared that the hole was about eighty yards by thirty. The colliery had been worked for fifty years, and there must have been a large space excavated; it was all filled with water in two hours and a half." A black gurgling whirlpool for some time marked the aperture through which the sea entered, at a considerable distance from the shore; and the air expelled by the water from the works rushed in strong squalls from the mouth of the shaft. Forty persons perished upon this occasion.

In the following year, 1838, at an adjoining mine, belonging to the same proprietor, the same number of lives were lost, in a different manner, but in one as distinctly the result of imprudent management. The foreman had gone down into the pit to examine it, and thirty-eight men had descended to await his report at the bottom of the shaft, when the explosion of fire-damp from his light drove them in an instant into corners of the space about them, and jammed them together in instantaneous death. Two men and a boy were at the time

in the act of descending near the pit's mouth; all were driven up into the air, but the boy and one of the men falling outside escaped; the other fell down the shaft, making, with the foreman, the forty victims. Cases of this description illustrate the necessity of those regulations in the working of mines, which experience proves to be needful for the protection of life, being enforced by competent authority, that, as far as possible, there may be no addition made by folly or neglect to the suffering occasioned by uncontrollable events.

In no other human occupation is toil so severe, and personal safety so constantly in peril, as in extracting the mineral from its subterranean bed, which contributes so much to social comfort at the surface, diffusing above-ground, light, heat, riches, and enjoyment. To a depth varying from six hundred to fifteen hundred feet, the pitman has to descend into the bowels of the earth; then to traverse dark and narrow passages, often extending from two to three miles, to his place of work; then to labour by a scanty glimmering of light, breathing an impure atmosphere, in a confined space, usually in a stooping posture, and sometimes lying on his side for eight or nine hours together, excavating the coal. Through the whole period of his daily task, from the moment of being swung off to be let down the pit till the surface is regained, he is not secure for an instant against some misadventure, causing the explosion of the gases generated in the labora-

tory of nature, which may reduce him in the twinkling of an eye to a scorched and blackened mass, without a feature remaining for affection to recognise. Or, if out of the range of the fiery tempest, the suffocating after-damp appears, and may claim him for its victim. It is right for us, while familiar with the genial warmth of the blazing hearth, to know the toil, suffering, and risk, involved in the extraction of the material of our domestic fires, in order that we may not selfishly enjoy our comforts, but be ready, as opportunity offers, to further those arrangements which the commonwealth has authority to make, with a view to preserve the lives of those specially exposed to danger.

While the material interests of our mining population have occupied a considerable share of public attention of late years, solicitude has also been expressed to supply the moral and religious wants of a rapidly increasing portion of the community. As in every other large section of the people, there are shocking instances of ignorance and demoralization presented by this; but it is only just to add, and a pleasing fact to state, that since the revival of religion in the land, at the close of the last century, some of the most striking examples of the sanctifying and sustaining power of the gospel of Christ have been exhibited by the miners of Cornwall, and the colliers of Durham.* In a

* The interesting tract, entitled "The Collier Boy and his Candle-box," published by the Religious Tract Society, furnishes a pleasing instance of the sustaining power of religion in the midst of an appalling accident occurring in a coal mine.

parliamentary record of accidents in mines, the following simple evidence of a workman occurs, and throws a relieving gleam over a gloomy subject: "We have been very fortunate in these pits, and one reason the men think is, because we meet together and pray every day in the dinner hour." Subject to physical hardship, and specially liable to a sudden and violent death, the individuals so circumstanced who receive the gospel, are distinguished by a vivid appreciation of its great truths, a frequent recurrence to them, and probably realize more of the strong consolations they are calculated to impart than any other members of the household of faith. But, be it remembered, that while its views of God in Christ pardoning the guilty, and making over to them the promise of fatherly protection to fortify amidst the dangers of life, with the assurance of eternal bliss to cheer the hour of death, are adapted peculiarly to this class of society, they commend themselves to all by special suitability to their condition, and must be humbly and believingly embraced, with a true penitence and living faith, or life will pass without hope, death will come as an enemy, and eternity bring with it the sentence of righteous retribution.

Dangers of another character, however, and affecting a different class, are also connected with mining. From the uncertainty which, to a considerable extent, attends the working of mines, a greater degree of speculation often waits upon this department of enterprise than

is consistent with ordinary prudence or Christian moderation. During the mania of 1824, a rage for wild mining operations spread over this country. Unprofitable investments were made in South America to an enormous extent, returning in ruin and disaster on the unfortunate shareholders. More recently, we have witnessed the fever for gold which the extraordinary discovery of the auriferous products of California has excited in multitudes. Even in our country, and at the present hour, the same desire for speculation drives many into mining adventure, who have neither the skill nor the capital requisite to pursue them with safety. It is well, then, in conclusion, to caution the reader against rashly following enticements of this nature should they cross his path, alluring him from his lawful calling and pursuits. "Godliness," let it be remembered, "with contentment, is great gain." To him who seeks first the kingdom of God and his righteousness, all things else shall be added; while "they that will be rich fall into temptation and a snare, and into many foolish and hurtful lusts, which drown men in destruction and perdition," 1 Tim. vi. 9.

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